A STUDY OF SLEEP PATTERN IN TYPE 2 DIABETES MELLITUS PATIENTS AND ITS CORRELATION WITH HbA1c

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MAY 2018

CERTIFICATE

This is to certify that the dissertation entitled **"A STUDY OF SLEEP PATTERN IN TYPE 2 DIABETES MELLITUS PATIENTS AND ITS CORRELATION WITH HbA1c"** by the candidate **Dr. SARAVANAN.V,** for M.D Physiology is a bonafide record of the research done by him during the period of the study (2015-2018) in the Institute of Physiology and Experimental Medicine, Madras Medical College, Chennai- 600 003.

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ABBREVIATION

S.NO	ABBREVIATION	EXPANSION
1.	AASM	American Academy of Sleep Medicine
2.	AHI	Apnea-Hypopnoea Index
3.	BMI	Body mass Index
4.	CSA	Central sleep Apnea
5.	DI	Desaturation Index
6.	ECG	Electrocardiogram
7.	EEG	Electroencephalogram
8.	EMG	Electromyogram
9.	EOG	Electro-oculogram
10.	LSAT	Lowest saturation of oxygen in blood
11.	NREM	Non rapid eye movement
13.	PSG	Polysomnography
14.	R&K	Criteria Rechtschaffen and A.Kales
15.	RDI	Respiratory disturbance Index
16.	REM	Rapid eye movement
17.	RERA	Respiratory effort related Arousal
18.	SDB	Sleep disordered breathing
19.	SWS	Slow wave sleep
20.	TRT	Total recording time
21.	TST	Total sleep time
22.	WASO	Wake after sleep onset
23.	FBS	Fasting Blood sugar
24.	PPBS	Post Prandial Blood sugar
25.	PSQI	Pittsburgh sleep quality index
26.	ESS	Epworth sleepiness scale
27.	HbA1c	Glycated Hemoglobin

CERTIFICATE - II

This is to certify that this dissertation work titled **"A STUDY OF SLEEP PATTERN IN TYPE 2 DIABETES PATIENTS AND ITS CORRELATION WITH HbA1c"** of the candidate **Dr .SARAVANAN.V** with registration Number **201515002** for the award of **M.D** in the branch of **PHYSIOLOGY** . I personally verified the urkund.com website for the purpose of plagiarism Check. I found that the uploaded thesis file contains from introduction to conclusion pages and result shows **2 percentage** of plagiarism in the dissertation.

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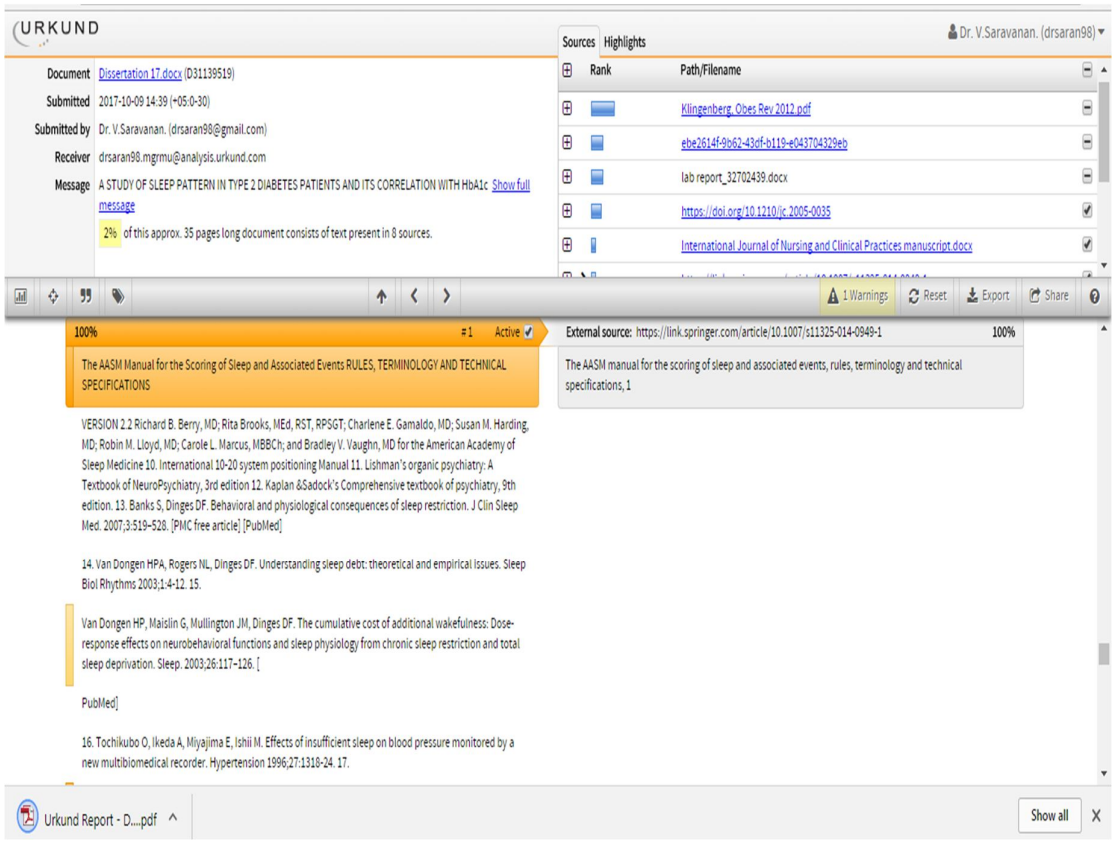


Introduction

INTRODUCTION

Sleep is a state of transient unconsciousness from which the person can be aroused by sensory or other stimuli [(1)]

Till the middle of the 20th century, sleep was thought to be a passive process. It was a common belief that our neurons become inactive and undergo a dormant phase. But recent studies showed that "during sleep our neurons are constantly in a firing state".

The role of sleep in balancing the mental and physical wellbeing of the individual is just beginning to gain importance as an area of research. Sleep is under the control of circadian rhythm. But the normal day-night cycle of human sleep is not seen nowadays. This has lead to the development of sleep medicine as a separate speciality.

Duration of sleep:

The duration of sleep for an individual depends upon the age, gender, occupation and various other factors. In general the duration of sleep declines with age. Children sleep for longer hours in a day. This helps in the regulation of hormonal secretion and thus the adequate growth of the child is ensured. Also sleep is necessary for consolidation of memory which is responsible for effective learning.

AGE GROUP	SLEEP DURATION
Newborns (0–2 months)	12 to 18 hours
Infants (3–11 months)	14 to 15 hours
Toddlers (1–3 years)	12 to 14 hours
Preschoolers (3–5 years)	11 to 13 hours
School-age children (5–10 years)	10 to 11 hours
Adolescents (10–17 years)	8.5 to 9.25 hours
Adults, including elderly	7 to 9 hours

Also the Rapid eye movement (REM) sleep duration depends on age-declining as age advances. Apart from age and other characteristics of an individual, emotions, food habits, daily activities, presence of illness and use of medications are the factors that decide the pattern and adequacy of sleep so that a person feels refreshed after waking up.

Sleep pattern may be disrupted by chronic illness and disrupted sleep pattern may also lead to the development of chronic illness.

Sleep Physiology :

The total duration of sleep could be broadly divided into two phases based on the electrophysiological parameters. They are REM and Non-Rapid eye movement (NREM) sleep. This can be recorded by a instrument called Polysomnogram. Polysomnogram is a instrument used to record biophysical changes during sleep.

The polysomnographic recordings vary in these two phases. These variations are cyclical that repeats every 90 minutes. Thus in a normal 6 to 8 hours sleep there occurs about four cycles.

SLEEP CYCLE :

Sleep cycle begins with NREM sleep, passes through four stages and ends with REM sleep. NREM sleep is otherwise called slow wave sleep and occurs in four stages 1 to 4. This cycle gets repeated every 70 to 90 minutes. The proportion of time taken for each stage varies according to age. The pattern of sleep is also characteristic for each individual. There also occurs brief periods of awakening of which the person is not aware (called stage W).

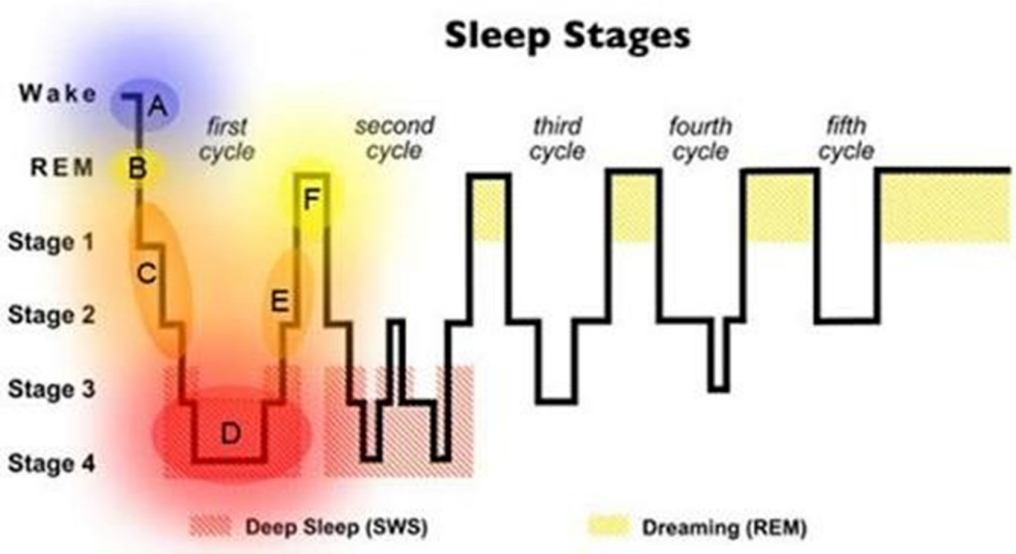


Figure 1 Stages of sleep cycle

Usually in the early part of night, deep slow wave sleep predominates. The first REM sleep may occur nearly after one hour of sleep onset. This interval becomes progressively shorter in the later part of night. Generally, about 25% of the total sleep period is occupied by REM sleep. As age advances the duration of REM and stage 4 sleep decreases. Newborns and infants spend about 50% of their sleep time in REM sleep.

EEG pattern during sleep:

In 1953, Aserinsky, Dement and Kleitman described the phases of normal sleep based on the EEG recordings. The normal recordings of EEG in different stages of sleep are as follows.

Stage of sleep	EEG findings
Wakefulness	β-waves : 14-30 Hz
Stage 1	Alpha rhythm
Stage 2	Sleep spindles and K-complexes
Stage 3& 4	Delta waves (slow wave sleep)
REM	High frequency, low amplitude waves,PGO spikes

Stage 2 sleep is considered to be the deep sleep. Delta waves are found to be the result of synchronized oscillations of thalamocortical circuit activity.

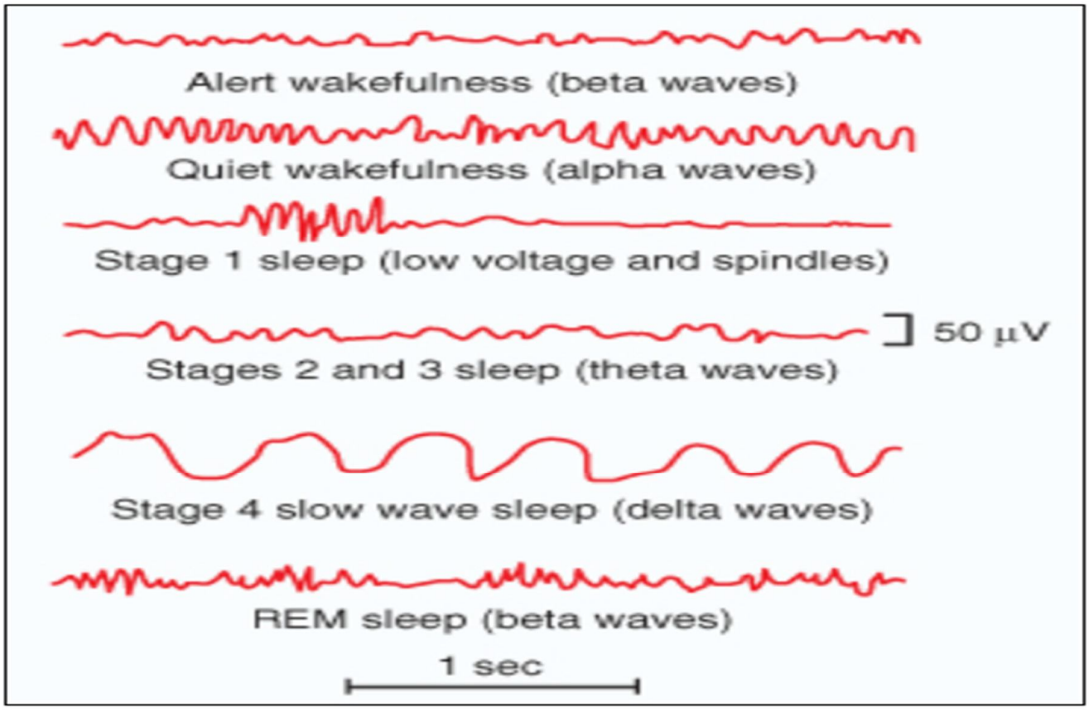


Figure 2 EEG pattern during sleep

NREM sleep :

EEG changes differ in the four stages of NREM sleep according to the depth of consciousness which increases as sleep progresses from stage 1 to 4. Progressively the EEG waves become slower in frequency and higher in voltage.

But the thinking in NREM could not be recollected as it is very short and rudimentary. Tone of the muscles is preserved and DTR could be elicited. EMG activity could be recorded in chin and limbs.

Autonomic activities in NREM sleep are widely decreased, with hypotension, bradycardia and decrease in cellular metabolic activities. Secretion

of hormones like Growth Hormone, Cortisol and Prolactin occurs. Also changes like increase in serotonin secretion is noted

Thus the early periods of sleep is predominantly NREM and later period shows a REM pattern with dream filled sleep which is comparatively lighter.

REM sleep:

This phase of sleep is characterized by rapid movement of eye ball and profound atonia of limbs sparing the respiratory muscles. About 50% of our total sleep is occupied by stage 2 sleep. Among the remaining half of the sleep duration about 20% is REM sleep and other stages constitute 30%. But in infants about half the duration is REM sleep. Recently it was proved that EEG findings in REM sleep are due to activation of proceruleus area in pons and atonia is due to activation of sublaterodorsal area.(Lu et al, 2006). These areas are called “REM on” areas and the ventrolateral Periaqueductal gray (PAG) and lateral pontine tegmentum are the “REM off” areas. These two areas mutually inhibit each other and act as a flip-flop switch which controls smooth transition between REM and NREM sleep. This switch is influenced by the balance between cholinergic neurons on the on-side and Noradrenergic and serotonergic neurons on the off-side of the REM sleep.

EEG shows more active pattern than NREM. Ocular movement artifacts are commonly seen. EMG record shows a flaccid pattern. But other activities of the body are like as if the person is awake.

Sleep Latencies:

"Sleep latency is the time interval from the time of retiring to the time at which the person falls asleep". Normal sleep latency is about 10-20 minutes in an otherwise healthy person. " the interval from falling asleep to occurrence of the first REM sleep in a sleeping individual is REM latency". It may take about 90-120 minutes within one cycle.

Disorders like presenile dementia, sleep apnea affect these two latencies or any one of them. Study of sleep latency gives a clue to diagnose those disorders.

DIABETES MELLITUS:

Diabetes is the most commonly occurring non-communicable disease in the world.it is one of the oldest diseases known to mankind. though the essential feature of diabetes is hyperglycemia, the causes are multifactorial and the disease affects almost all the organ systems in the body. So it is actually a syndrome resulting from interactions between genetic, environmental and behavioural factors.

EPIDEMIOLOGY:

The WHO fact sheet for diabetes in the year 2014 states that around 422 million people are affected with diabetes. The global prevalence has increased from 4.7% in 1980 to 8.5% in 2014. WHO predicts that Diabetes will be the 7th leading cause of death in the world by 2030. [(2)]

INDIAN STATISTICS:

India topped the world with 31.7 million diabetics in the year 2000. It is estimated that by 2030 the number of diabetics in India will become 79.4 million. The etiology of diabetes in India is again multifactorial with increasing obesity being the main cause. The rapid urbarnisation with lifestyle changes in the past few decades have contributed for the escalating rates of occurrence of diabetes in India. Also obtaining a uniform statistics is difficult due to wide variations in the diet and cultural practices across the country.[3]

CLASSIFICATION OF DIABETES:

Diabetes is broadly classified as Type 1 and Type 2 diabetes. This classification is based on the pathophysiology that leads to hyperglycemia. Accordingly the etiological classification of diabetes is as follows. [4]

I.Type 1 diabetes (βcell destruction, usually leading to absolute insulin deficiency)
- A. Immune mediated
- B. Idiopathic

II. Type 2 diabetes (may range from predominantly insulin resistance with relative insulin deficiency to a predominantly secretory defect with insulin resistance)

III. Other specific types
- A. Genetic defects of βcell function
- B. Genetic defects in insulin action
- C. Diseases of the exocrine pancreas
- D. Endocrinopathies
- E. Drug or chemical induced
- F. Infections
- G. Uncommon forms of immune-mediated diabetes
- H. Other genetic syndromes sometimes associated with diabetes

IV. Gestational diabetes mellitus

TYPE 1 DIABETES MELLITUS: (Insulin dependent diabetes mellitus)

Type 1 diabetes is characterized by hyperglycemia produced due to complex disease process that mostly occurs after sudden onset of an auto immune process owing to genetic and environmental factors.The pancreatic β cells of the islets of langerhans are destroyed during this process resulting in insufficient insulin production .Administration of exogenous insulin remains the main stay of treatment.

TYPE 2 DIABETES MELLITUS:

Previously known as non-insulin dependent diabetes or adult onset diabetes. Individuals with this disorder have predominantly insulin resistance with relative insulin deficiency. This accounts for about 90-95% of the diabetic population in the world.

The stage before the development of overt diabetes is called impaired glucose tolerance or prediabetes.The current diagnostic criteria for diagnosis of Type 2 Diabetes mellitus is as follows. [5]

1. **Casual plasma glucose ≥ 200 mg/dl plus classical symptoms.**

or

2. **Fasting plasma glucose (FPG) ≥ 126 mg/dl**

or

3. **2- hr Plasma glucose ≥ 200 mg/dl on 75-gm oral glucose tolerance test**

or

4. **HbA1c ≥ 6.5% using standardised lab method.**

RISK FACTORS:

Type 2 DM is a result of interplay between genetic and metabolic factors.Ethinicity, family history of diabetes, unhealthy diet, physical inactivity smoking and previous gestational diabetes increase the risk.

- Family history of diabetes (i.e., parent or sibling with type 2 diabetes)
- Obesity (BMI 25 kg/m^2)
- Physical inactivity
- Race/ethnicity (e.g., African American, Latino, Native American, Asian American, Pacific Islander)
- Previously identified with IFG, IGT, or an A1C of 5.7–6.4%
- History of GDM or delivery of baby >4 kg (9 lb)
- Hypertension (blood pressure 140/90 mmHg)
- HDL cholesterol level <35 mg/dL (0.90 mmol/L) and/or a triglyceride level >250 mg/dL (2.82 mmol/L)
- Polycystic ovary syndrome or acanthosis nigricans
- History of cardiovascular disease

Of all the above risk factors Obesity is the often an associated feature or the affected individuals atleast have increased percentage of body fat mainly deposited around the abdomen. Obesity related complications are frequently associated with this type of diabetes. Persons withthis type of diabetes often have

comorbidities like hypertension, obstructive sleep apnea etc. and also are more likely to develop metabolic syndrome.

Obstructive sleep apnea(OSA) is frequently associated with obesity and as obesity is a risk factor for diabetes, persons suffering from OSA tend to develop diabetes mellitus.

COMPLICATIONS OF DIABETES:

Diabetic ketoacidosis and Non-ketotic Hyperosmolar coma are the acute complications of Type 1 and Type 2 DM respectively. These two conditions are treated as emergencies in diabetes.

Since the basic pathology is Hyperglycemia Diabetes Mellitus has impact on almost all organs and systems of the body.the incidence of complications increase with chronicity of the disease. Sometimes the complications may be the presenting feature that leads to a diagnosis of diabetes.

Complications can be considered in two broad groups – vascular and non-vascular compilcations. Vascular complications may be due to microvascular events or macrovascular events. The commonest chronic complications of Diabetes mellitus are listed below.

Microvascular
1. Eye disease
Retinopathy (nonproliferative / proliferative)
Macular edema
2. Neuropathy
Sensory and motor (mono- and polyneuropathy)
Autonomic
3. Nephropathy
Macrovascular
1. Coronary heart disease
2. Peripheral arterial disease
3. Cerebrovascular disease
Other
1. Gastrointestinal (gastroparesis, diarrhea)
2. Genitourinary (Infections/sexual dysfunction)
3. Dermatologic
4. Infectious
5. Cataracts
6. Glaucoma
7. Periodontal disease
8. Hearing loss

Glycated Hemoglobin:[6]

These are minor variant of adult hemoglobin (HbA) to which glucose is attached to the N-terminal valine residue of the β-chain. By chromatographic techniques this group of molecules can be seperated into HbA1a(1.6%), HbA1b(0.8%) and HbA1c(3-6%). Since the concentration of HbA1c forms the major share, measurement of this fraction is considered as the total measure of glycated hemoglobin.

Conversion of HbA to HbA1c is possible throughout the lifespan of RBC. So its concentration is higher in older RBCs and the rate of conversion is greater in diabetics as the plasma glucose levels are higher. So measurement of HbA1c can be used to diagnose DM.

Also the life span of HbA1c is longer and so the levels of glycated hemoglobin reflect the blood sugar levels over a period of 12 weeks. Thus HbA1c measurement is a good parameter to assess diabetic control over the previous 4-6 weeks. And these measurements correlate with the complications of diabetes mellitus also. [7]

Methods to study normal sleep:

Sleep could be either studied by clinical observation or by recording the physiological information using the instruments.

The instrumental recording of the physiological changes during sleep could be done by recording a polysomnography.

Polysomnography as a term was coined in 1974 by Holland, Dement and Raynall as this method employs recording of of Electro encephalogram (EEG), Electro oculogram (EOG),Electromyogram (EMG), Electrocardiogram (EKG), vital signs and breathing parameters.

Polysomnography is actually a technique of comprehensive recording of biophysiological changes during sleep along with the analysis and interpretation of results. Standardised scoring manual are available with universally uniform terminology and specifications. A.Rechtschaffen and A.Kales in 1968 were the first persons to bring out a manual for sleep study and its interpretation (popularly known as R & K criteria).[8]

American Academy of Sleep Medicine (AASM) incorporated comprehensive rules for scoring and terminologies for interpretation in 2007.[9]

The **AASM** terminologies are as follows.

1. N denotes NREM sleep
2. R denotes REM sleep
3. N1 and N2 are stage 1 and stage 2
4. N3 is sum of stage 3 and stage 4
5. The post auricular placement of electrodes are called M1 and M2 instead of A1 and A2.

Clinical polysomnography classically records the EEG during sleep with the help of the electrodes placed on the scalp according to the standardized international 10-20 system.[10]

In addition to this others parameters that are recorded are

1. EMG in the anterior tibialis muscle
2. Plethysmography to record respiratory effort
3. Nasal and oral airflow
4. Pulseoximetry to measure oxygen saturation
5. EOG to record the eye movements
6. Audiovisual means are used to record the gross body movements
7. ECG

Recording is done in a thermal paper like ECG. This paper length is divided into segments of time for convenient reporting. Each segment is called an EPOCH. The paper speed for recording is 10 mm/s and a 30 cm page represents 30 secs recording. This forms an epoch. Even after digitalization of the polysomnogram scoring is done conventionally using a 30 sec epoch window.

PREREQUISITES FOR CONDUCTING POLYSOMNOGRAPHY

- Air conditioned room with attached bathroom
- Polysomnographic recording system
- Computer
- Amplifiers
- Electrodes and application material
- Pulse oximeter-to detect blood gas analysis
- Abdominal and thoracic belts-to detect respiratory effort
- Nasal airway pressure transducer- to detect nasal airflow
- Access to emergency medical care

Recording system includes :

- Quality amplifier
- Filter design and configuration
- Independent filter selections for each channel
- Adequate sampling rates and bit resolution for each recorded parameter
- Input signal referencing capabilities
- Provisions for standard calibration procedures and signal verification
- Appropriate signal display

Analog type instrument or a digital instrument can be used for recording. The digital recorders need computers for data analysis. Advantage of digital instruments is that data could be store for future retrival. A typical device may

store upto 50 megabytes of data for an 8 hour recording. This data could be downloaded to a computer and analysed using appropriate software.

Sources of signal

Three signalsources in polysomnography are:

1. Bio electric potentials like EEG, EOG, EMG, ECG
2. Trasnduced signals from the sensors attached to the patient like plethysmography, body position sensors etc.
3. Ancillary equipment signals like pulseoximeter.

All the above mentioned instruments are provided with their own processor circuits, display and output.

Amplifiers :

A direct amplifier records slowly changing potentials as from a pulse oximeter. The alternating current amplifier records high frequency potentials as from the EEG, EOG etc. A differential amplifier amplifies the difference between electrode inputs instead of the absolute voltage at any electrode. The contamination from the electrical noise is prevented by subtracting it out. This ability of the amplifier to suppress an unwanted signal is called common moderejection.

FILTERS:

Use of filters helps to remove the unwanted signals that escape the differential amplifier.

Filters are of different types:

- High frequency filter (HFF)- attenuates the higher frequency amplitude signals above the cut off value and thus determines the highest frequency that a channel would display.

- Low frequency filter (LFF)-attenuates the lower frequency signals below the cut off value and thus determines the lowest frequency that a channel would display.

- Notch filter – eliminates 50 or 60 Hz frequency interference from amplifier output.

- Digital filter –deltes selected frequencies after digital conversion of the amplified signals using software algorithms.

DIGITAL SPECIFICATION FOR ROUTINE POLYSOMNOGRAPHY (AASM GUIDELINES)

Electrode	Desirable sample rate(Hz)	Minimal sampling rate (Hz)	High frequency filter (Hz)	Low frequency filter (Hz)	Maximum impedance (K Ohms)
EEG	**500**	**200**	**35**	**0.3**	**5**
EOG	500	200	35	0.3	5
EMG	500	200	100	10	
EKG	500	200	70	0.3	
Snoring	500	200	100	10	
Airflow	100	25			
Oximetry	25	10			
Chest and abdominal movement	100	25			
Body position	1	1			

MEASUREMENT OF SIGNALS:

Signals recorded are measured according to

1. Frequency- the number of waves appearing per second that is cycles per second or Hertz
2. Amplitude – Amplitude is the measure of the electrical voltage. Vertical height of a wave represents the amplitude.

This independent on the sensitivity setting of the amplifier .Sensitivity is the voltage needed to produce a set deflection of the pen. It is inversely proportional to the amplitude.

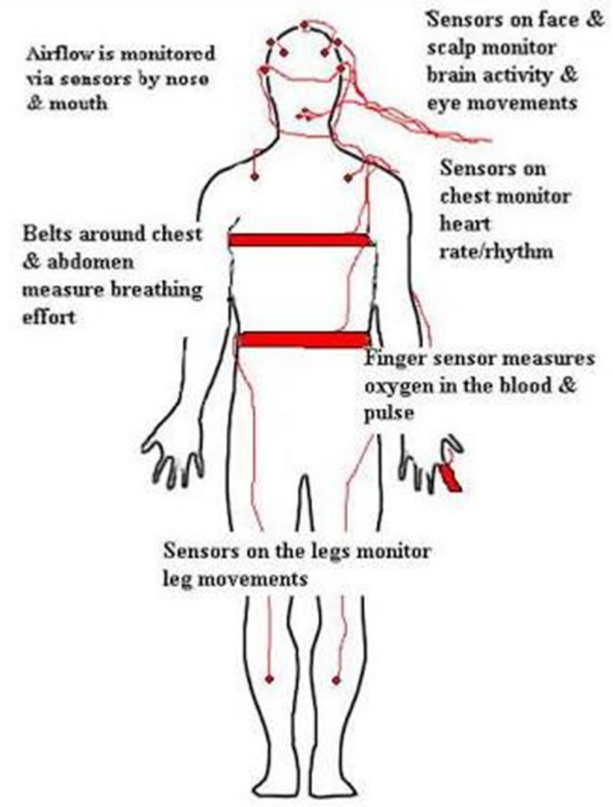


Figure 3 Leads of Polysomnography

Thus the actual process by which the electrical signals from the patient are converted to digital data is as follows.

Signal pathway and Processing in Polygraphic Circuit

Electrical signal produced in the patient's body

↓

Signal is transmitted from the skin to the electrode

↓

From the electrode through lead wire it goes to head box

↓

From head box it goes to differential amplifier through a shielded cable

↓

Differential amplifier subtracts a reference signal and a ground signal from the original signal using a method called COMMON MODE REJECTION

↓

The new signal is sent to polysomnograph

↓

DC devices send other data about the patient through DC amplifier to polysomnograph

Review of literature

REVIEW OF LITERATURE

Sleep – a necessity for survival.

"Why animals and humans sleep?" is a still unanswered question. However our performance during wakefulness, physical and mental health is highly dependent on the quality of our sleep. Brain development may be related to the sleep pattern. This may be explained by longer duration of deep sleep among infants.[11]

Functions of sleep:

Again the functions of sleep is also a query for which the answers are being still formulated. But all animal species sleep and so sleep can be regarded as rest period for the organ systems that were continuously working during wakefukness. Cessation or reduction of the metabolic activity during sleep serves this purpose. The brain is the most benefitted organ during sleep. This particular organ replenishes its energy stores during sleep.so the most important function of sleep is brain restitution. Sleep plays a role in learning and consolidation of memory.[1]

Physiological changes during sleep:

During sleep the physiological activities of the organ systems vary from that of during wakefulness. There is increased parasympathetic tone with reduced sympathetic activity. As a result the heart rate, blood pressure and respiratory rate are lower during sleep. Due to muscle relaxation the upper airway resistance increases particularly in REM sleep. Body temperature is lower than normal

especially during slow wave sleep. Sleep also has a important role in regulation of hormone secretion.[12]

Sleep deprivation:

The condition when an individual does not get adequate sleep is called sleep deprivation.this may be due to organic sleep disorders per se or may be a behavioural disorder.

When an individual does not go bed according to their biological clock and continue to be in the wakeful state than for an expected duration it is called total sleep deprivation. This will be usually followed by compensatory sleep that restores the normal sleep cycle.

Partial sleep deprivation is when an individual goes to bed but the quality and quantity of sleep is not optimum. This partial deprivation of sleep can occur in three ways. One is fragmentation of sleep (eg. Obstructive sleep apnea). This condition is characterised by disrupted progression in the sequence of stages of sleep. Second type of partial sleep deprivation is loss of specific stages of sleep and can be denoted as selective sleep deprivation. Third type sleep restriction which is typically reduced duration of sleep.[13,14]

Effects of sleep deprivation:

Brain is the primary organ that is highly dependent on sleep for its normal functioning than other organ systems. The immediate effect of both acute and

chronic sleep deprivation is cognitive impairment. Apart from this sleep deprivation also causes mood changes and neuroendocrine changes.[15]

As a result of these changes the metabolic processes of the body are also altered when the individual suffers sleep deprivation particularly of the partial type. Many physiological indices are altered due to short term sleep restriction. Some of them are increase in BP, [16] sympathetic nervous system activation[17], decreased levels of leptin[18], high production of inflammatory markers.[19]

Numerous endocrine metabolic changes are also seen after sleep deprivation or sleep restriction. Some of these effects are increase in serum cortisol levels in an evening sample, decreased thyrotropin activity and above all the most important is the impaired glucose tolerance. [20]

This impaired glucose tolerance is the preliminary stage of diabetes mellitus.

SLEEP and DIABETES:

Behavioural sleep restriction has become a necessity nowadays due to globalization, lifestyle changes and work pattern modifications.Currently there are authenticated evidences that behavioural sleep restriction has increased the incidence of obesity and diabetes. Three mechanisms are proposed for the development of obesity and diabetes in sleep deprived individuals. 1. alterations in glucose metabolism; 2. upregulation of appetite; 3. decreased energy expenditure.[21]

Sleep and Glucose metabolism:

As the overall metabolic rate decreases during sleep so does the glucose metabolism. In the first half of night the metabolism of glucose is slower due to predominance of slow wave sleep which is associated with lowered cerebral glucose uptake and reduced peripheral glucose utilisation. These effects are reveresed in the second half of the night which is characterised by increase in frequency of REM sleep.[22,23]

Glucose tolerance is the ability of the body to secrete insulin according to the plasma glucose levels so as to activate the glucose metabolism and return blood glucose to normoglycemic levels. this is highly dependent upon the pancreatic beta cell function to secrete required quantities of insulin and the ability of the insulin to adequately metabolise the blood glucose. Reduced Insulin sensitivity or insulin resistance is a condition which denotes the requirement of larger amount of insulin to bring back the normoglycemic states when there is altered levels of blood glucose. This glucose tolerance is at its minimum during the night than in the morning and so insulin resistance is higher in the night. [24]

Sleep and appetite:

Food intake is normally regulated by two different neuronal areas in hypothalamus – the appetite stimulating and appetite suppressing areas. These two areas are influenced by two peripheral signals the leptin and ghrelin. Leptin promotes satiety and decreases food intake while ghrelin induces hunger and increases food intake.[25,26,27]

During normal conditions there is a nocturnal rise of plasma leptin and ghrelin levels . the ghrelin levels come down in the later part of night and so the appetite is suppressed during normal sleep. Sleep deprivation in rodents have resulted in hyperphagia.

This is because of the action of another hormonal substance called orexin. Orexin acts upon the lateral hypothalamus and stimulates the secretion of neuropeptide Y which increases the food intake. Orexin also influences certain neuronal areas that maintain wakefulness. Thus by maintaining wakefulness orexin promotes eating behavior also.[28]

There is evidence of irregular eating habits, in between meal snacking, execessive seasoning of food and less intake of vegetables associated with sleep deprivation.[29]

A previous study conducted on 12 healthy volunteers with 2 days of sleep restriction and 2 days of sleep extension under controlled intake of calories and physical activity showed significant increase in hunger and food intake especially of high calorie value with significant increase in ghrelin levels and decrease in leptin levels. [30]

One another study examined the changes in energy intake and energy expenditure along with leptin and ghrelin levels with respect to normal and restricted sleep duration. Eleven healthy volunteers participated in this study in an inpatient basis and sleep was recorded using a polysomnography consisting of

EEG, EOG and EMG. The results showed significant increase in consumption of snacks and carbohydrate rich food during restriction of sleeping hours with no significant changes in serum leptin and ghrelin levels [31]. Thus sleep deprivation causes increase in energy intake and decrease in energy expenditure which may lead to obesity – an important predisposing factor for diabetes.

Sleep and energy expenditure:

Energy expenditure plays a major role in controlling increase in body weight and development of obesity. Total energy expenditure (TEE) of the body depends upon the resting basal metabolic rate(RMR), thermogenic effect of meals (TEM) and activity related energy expenditure(AEE). In most persons this AEE is determined by the non-exercise activity thermogenesis (NEAT) which is the energy loss during normal physical activities ike sitting, standing, walking etc.[32] Weight loss and prevention of obesity depends upon the AEE and NEAT. Obese individuals have lower levels of NEAT than non obese individuals.[33] Subjects with sleep disorders both organic and behavioural report execessive daytime sleepiness and reduced physical activity which in turn would reduce the AEE. Thus contributing to increase in weight gain.[34]

All the above discussions point that sleep deprivation through various mechanisms as summarised in the figure below leads to development of diabetes.

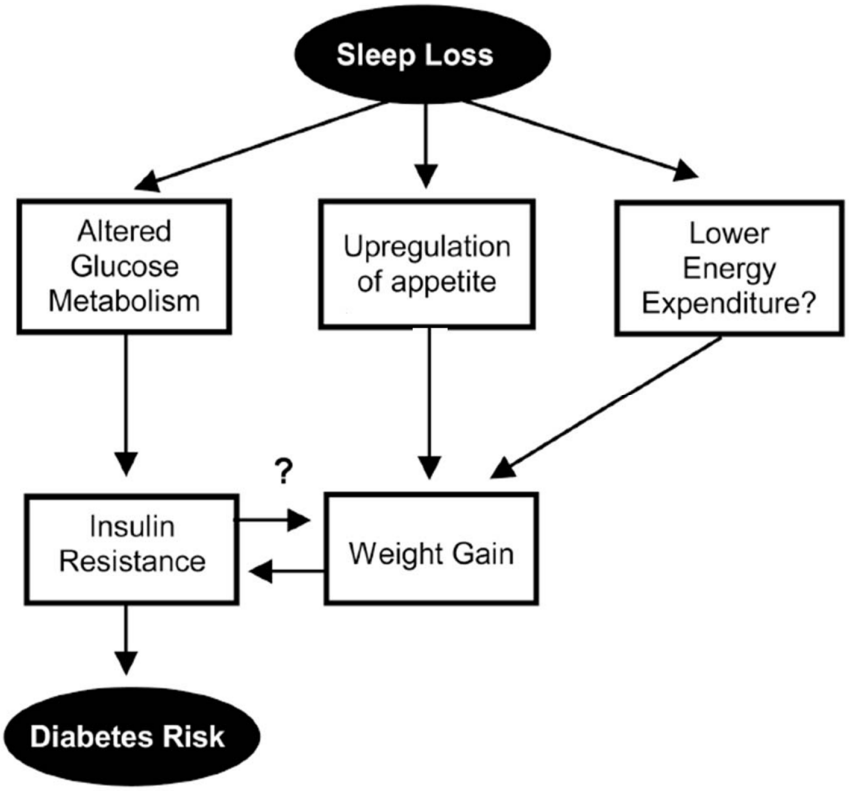


Fig 4 Mechanism of Sleep deprivation for Diabetes

Sleep disorders and diabetes:

So far we have discussed about the effect of behavioural sleep restriction on diabetes.also organic sleep disorders may also lead to the development of diabetes. The sleep disorders are classsified into seven broad categories according to the international classification of sleep disorders (ICSD 3) (35) As follows.

1. insomnia disorders
2. sleep-related breathing disorders
3. central disorders of hypersomnolence
4. circadian rhythm sleep-wake disorders

5. sleep-related movement disorders
6. parasomnias
7. other sleep disorders.

These sleep disorders when not adequately treated,through various mechanisms lead to the development of diabetes as outlined in the following figure.

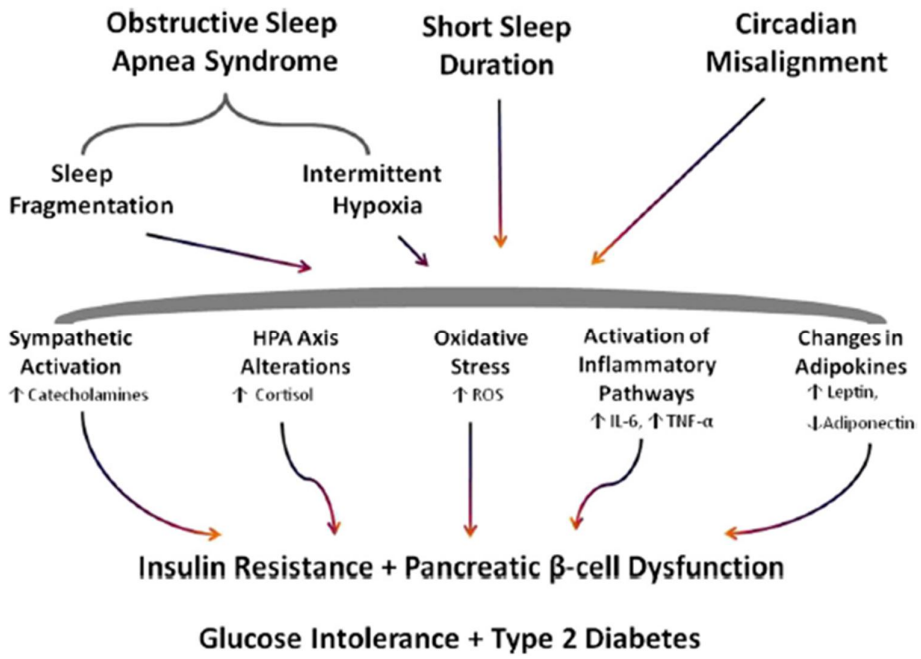


Figure 5 Mechanism of Sleep depreviation causes Glucose intolerance

When the effects of sleep deprivation on HPA axis were studied in three groups of subjects- one with normal sleep, second with partial sleep deprivation and the third with total sleep deprivation the cortisol levels were measured during the evening following sleep deprivation were higher in both the sleep deprived groups in comparison to that measured during the previous day. In the normal

sleepers there is no such increase.[36] this sleep deprivation induced HPA axis hyperactivity is involved in metabolic consequences like obesity, diabetes etc.[37] The circadian rhythmicity also plays a great role in metabolic processes particularly glucose homeostasis. Nutrition has been identified as a potential zeitgeber[38]. In animal models melatonin and melatonin receptor agonist administration influence the glucose homeostasis in various ways like increase in glucose uptake by the tissues, increase in glucose induced insulin secretion, better insulin sensitivity and lower rates of gluconeogenesis [39].

Also melatonin increase glycogen synthesis in liver[40], limits fat accumulation and adiposity in humans[41], thus preventing obesity. So distruption of the circadian rhythm due to various conditions like shift work, repeated travel across time zones may result in metabolic derangements in glucose homeostasis. Both cross-sectional and retrospective studies on shift workers show an increased incidence of type 2 diabetes mellitus[42], glucose intolerance[43], insulin resistance[44] and metabolic syndrome [45].

Obstructive Sleep Apnoea (OSA)is a common sleep disorder which is increasing in prevalance with the increase in obesity. [46]

OSA is characterised by intermittent hypoxia and frequent arousals thus causing disrupted sleep pattern. OSA being an independent risk factor for cardiovascular disease is also implicated as a causative factor in various metabolic derangements like dyslipidemia, insulin resistance, glucose intolerance and type 2 diabetes mellitus.[47,48] OSA causes intermittent hypoxia which is implicated as a

cause for these metabolic derangements evidenced by presence of insulin resistance even in non- obese OSA patients. [49]

As outlined in the figure below intermittent hypoxia acts on different insulin sensitive tissues and organs by various mechanisms and leads to development of diabetes.[50]

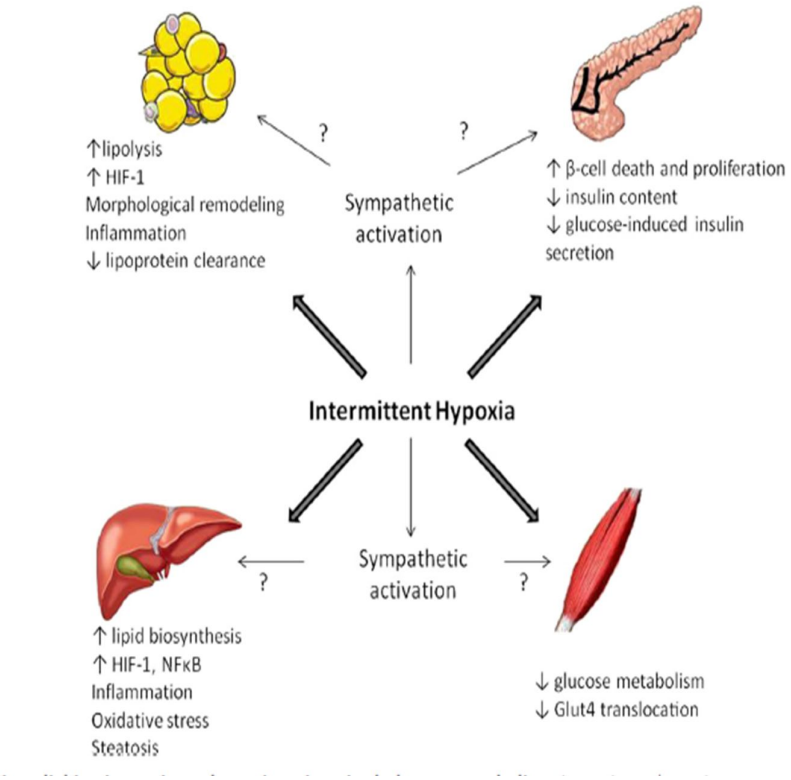


Figure 6 Mechanism of intermittent hypoxia causes insulin resistance

Intermittent hypoxia causes sympathetic activation and thus elevated levels of circulating of catecholamines.[51,52]. The epinephrine released during sympathetic activation causes a trigger in glucose production and impairment in insulin secretion resulting in insulin resistance.[53]

Another hallmark finding in OSA is sleep fragmentation, a condition where total sleep duration is not altered but there is discontinous sleep with altered architecture. Experimental studies inducing sleep fragmentation with auditory and mechanical stimuli showed a decrease in insulin sensitivity which is not compensated by increase in insulin secretion suggesting that sleep fragmentation alters glucose homeostasis[54,55]. Also as evidenced by wrist actigraphy the type 2 diabetes patients manifest sleep fragmentation.[56] the actigraphy performed on diabetics showing sleep fragmentation is associated with higher fasting blood glucose when compared with non diabetics.[57]

Sleep and glycemic control:

There are evidences to show that sleep deprivation may cause increased risk for developing diabetes. Sleep deprivation also causes some adverse changes in existing diabetic status. A survey study done on 161 type 2 diabetes patients concluded with a predicted increase of HbA1c for a 3 hour sleep debt per night as 1.1% above the median and 1.9% above the median for a 5 point increase in Pittsburgh sleep quality index (PSQI)scores.[49]

A previous study conducted on 118 subjects with type 2 diabetes found that sleep duration and segments of short naps significantly predicted the HbA1c levels. There was a reduction of HbA1c by 0.174% with an increase in duration of sleep by onehour. So authors have concluded that increasing the duration of sleep and short naps inbetween improves the glycemic control.[50]

In another study conducted on geriatric diabetic patients the was a relationship between sleep quality and glycemic control when the reference value of HbA1c was fixed at 7% there was approximately a four fold increase in HbA1c levels when there was an increase in Epworth sleepiness scale (ESS) scores.[51]

A cross sectional study conducted on 1022 japanese healthy adults in the age group of 22-69 yrs. showed a significant positive linear correlation of high HbA1c with insomnia symptoms like difficulty in maintaining sleep and early morning awakening.[52]

In one another previous study 46 type 2 diabetes patients were investigated for glycemic control with HbA1c and quality of sleep assessed using PSQI. After adjusting for age, gender and BMI the PSQI scores significantly correlated with HbA1c in the positive direction. [53]

Quality of life in diabetic patients was assessed with quality of life index questionnaire and quality of sleep using PSQI. Quality of life in diabetics was dependent upon the quality of sleep. In turn the sleep duration positively correlated to HbA1c levels and fasting blood glucose. HbA1c negatively correlated with PSQI scores suggesting that lower HbA1c is associated with good sleep quality.[54]

Evidences are present for elevated HbA1c in diabetic patients engaged in shift work and the insufficient glycemic control was linked to the duration of hours of shift work and duration of employment in the shift work.[54,55]

In a previous study of polysomnography on 60 type 2 diabetes patients about 77% of them had OSA and the severity of OSA was significantly associated with poor glycemic control as evidenced by increased levels of HbA1c.[56]

How diabetes affects sleep:

Sleep and diabetes has a bidirectional relationship. Poor sleep quality leads to diabetes and presence of a diabetic state leads to poor quality of sleep. The proposed mechanisms for poor sleep quality in diabetes can be summarized in the following figure.

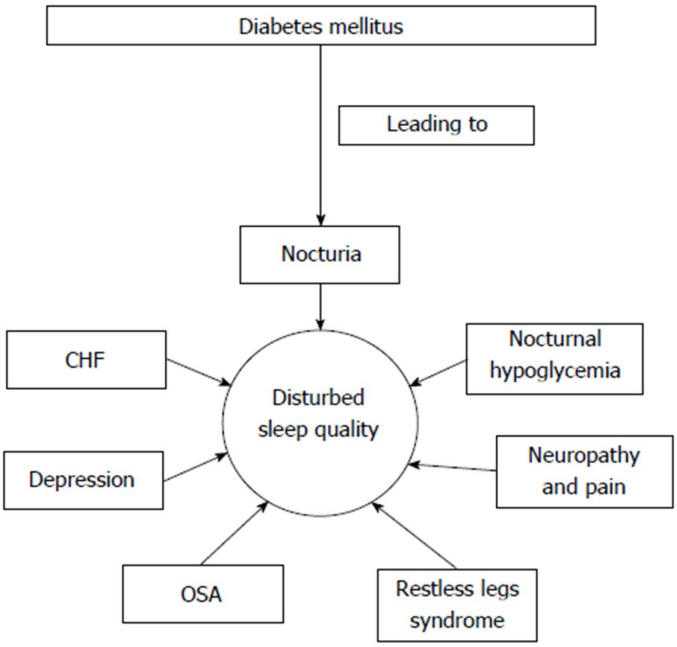


Fig 7 Mechanism of Diabetes for poor quality of sleep

Nocturia is waking up in the night to void.Nocturia causes sleep disturbance by frequent awakening thus affecting both onset and maintenance of sleep [57]. Polyuria a feature of diabetes can lead to nocturia through distension of bladder beyond its capacity or through solute diuresis. Another mechanism involved is diabetic patients with associated OSA is the stretching of myocardium due to the negative intrathoracic pressure resulting in release of Atrial Natriuretic Peptide that causes excess sodium and water excretion [58]. In a previous study done on 74 type 2 DM patients nocturia was found to be associated with sleep maintenance difficulties thus reflecting poor quality of sleep [59].

Another cause for sleep disturbance in diabetes may be nocturnal hypoglycemia. This is more consistent with type 1 diabetes where hypoglycemic episodes are frequent. Studies have shown that most of the hypoglycemic episodes occur at night [60].

Restless Leg Syndrome (RLS) is a sensorimotor disorder characterised by an irresistible urge to move the legs that is aggravated by rest and relieved by movement, the symptoms classically worsen at night [61]. Evidences show that there is increased risk of RLS in diabetic patients [62]. Type 2 DM patients with co-morbid RLS report poor sleep quality and efficiency characterised by prolonged sleep latency resulting in more daytime dysfunction than diabetics without RLS[63].

Obstructive sleep apnea (OSA) is one of the sleep disordered breathing. This leades to apneic episodes causing intermittent hypoxia, frequent arousals causing sleep fragmentation, reduction in Total Sleep Time (TST) causing daytime sleepiness.[64] the intermittent hypoxia in OSA patients has been investigated as a chief cause of insulin resistance through increase in sympathetic activation and serum cortisol levels.[65]

In a polysomnographic study conducted on 306 type 2 diabetes patients about 86% of the participants had OSA with approximately 22% had severe OSA and 30% had moderate OSA[66].

Another study on diabetic patients with poor glycemic control with HbA1c $\geq$ 7% revealed a prevalence of 37.2% for OSA among this group[67]

Diabetic patients both type 1 and type 2 have increased risk of cardiovascular problems particularly congestive cardiac failure(68,69). These diabetic patients with co morbid heart disease also have disturbed sleep due to various reasons like dyspnea,orthopnea, paroxysmal nocturnal dyspnea,OSA, pain, medication effects etc[70].

A review article published in 2012 states that there is a close relation between sleep, aging and meatbolic syndrome. Diabetes being one of the components of metabolic syndrome is closely associated with sleep disorders and sleep disorders in turn lead to early development of diabetes and poor glycemic

control in existing diabetes. The relation between diabetes and sleep could be expalined by the following flow chart[71].

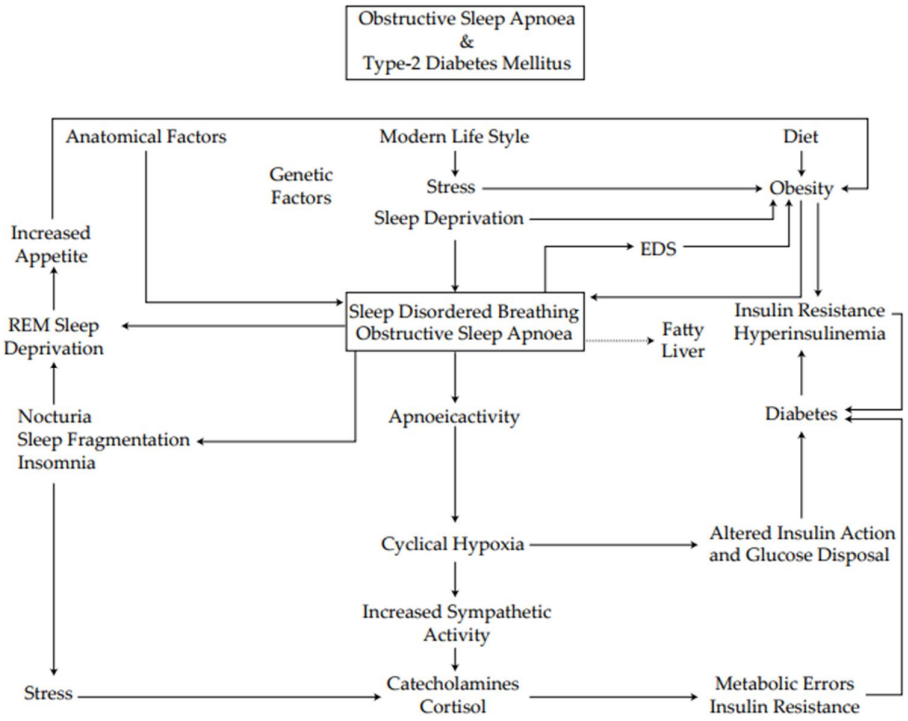


Fig 8 . The relation between diabetes mellitus and sleep

Aim and objectives

AIM AND OBJECTIVE OF THE STUDY

The primary aim of the study is to investigate the sleep pattern in type2 diabetes mellitus patients in relation to their HbA1c.

OBJECTIVES :

1. To assess the polysomnographic parameters in type 2 diabetes mellitus patients
2. To assess the sleep pattern relation with HbA1c level.
3. To assess the sleep pattern relation with duration of Type 2 diabetes mellitus.
4. To assess subjective daytime sleepiness using Epworth Sleepiness Scale in type 2 diabetes mellitus patients
5. To assess the quality of sleep using Pittsburgh Sleep Quality Index in type 2 diabetes mellitus patients

Materials and methods

MATERIALS AND METHODS

The place of the study was the Institute of Physiology and Experimental Medicine, Madras Medical College. The study duration was May 2016-April 2017. Approval to conduct the study was obtained from the Institutional Ethics Committee (IEC), Madras Medical College, Chennai.

Subjects for the study group were recruited from the Institute of Diabetology, RGGGH, Chennai.

Subject selection:

Study population consists of 30 patients of both genders in the age group of 40-60yrs diagnosed with and undergoing treatment for Type 2 diabetes mellitus.

Thirty subjects matched for age and gender with normal blood sugar levels and HbA1c levels were taken as controls.

Inclusion criteria:

Patients diagnosed with and on treatment for Type 2 Diabetes of any duration, both men and women in the age group of 40 – 60 years were included in the study.

Exclusion criteria:

Subjects with the following conditions were excluded from the study.

- Type 1 diabetes mellitus
- Patients regularly taking sleep medications
- Psychiatric illness
- Obstructive sleep disorder
- Pregnancy and post-partum period
- Patients with secondary infections
- Neoplastic, hepatic, respiratory and any cardiovascular disorders
- Other concurrent medical illness like renal failure, cardiac failure etc.
- Subjects taking medications that influence sleep pattern

According to the above inclusion and exclusion criteria subjects were recruited for the study after obtaining informed consent both in the verbal and written form.

Study design: Cross sectional study

Methodology :

After obtaining informed consent, the participants of the study were subjected to the following investigations.

- Blood glucose levels- fasting and postprandial with Glycated Hemoglobin.
- Polysomnography.

Sample collection

Under universal precautions 5 ml of venous blood sample was taken in the fasting state.

The sample is centrifuged at 3000 rpm for 10 secs and serum separated and stored in the deep freezer at -20℃. The samples were sent to the central laboratory at RGGGH under the Institute of Biochemistry and analysed for FBS, and HbA1c.

After 2 hours post prandial sample was also collected in the same manner for estimation of PPBS.

Storage of FBS, PPBS samples

Estimation of FBS and PPBS

FBS and PPBS was measured in the unhemolytic serum samples by Trinder's method using the principle of oxidation of glucose to gluconic acid and hydrogen peroxide. A peroxidase enzyme generates a coloured quinonemine complex whose absorbance is proportional to the concentration of glucose in the sample.

The values were analysed according to the diagnostic criteria.

Subjects with FBS < 126 mg/dl and PPBS<200 mg/dl were considered as non- diabetics.

Those with FBS>126 mg/dl and PPBS> 200 mg/dl were included in the study group.

Estimation of HbA1c

Glycated hemoglobin was measured in a whole blood sample by particle enhanced immuno turbidimetric method using mouse and goat IgG monoclonal antibody. In this method HbA1c can be measured without measuring the total hemoglobin.

Values were interpreted as follows.

- Subjects with <6.5% were included in the non diabetic group.
- Subjects with >6.5% were included in the study group.

Storage of HbA1c samples

Polysomnography

Digital polysomnography was done for the consented persons using the MEDICAID SC32 in the human experiments laboratory of Institute of Physiology and Experimental medicine. A battery of noninvasive tests were done and the parameters measured are

- Electroencephalogram (C4/A1, C3/A2)
- Electro-oculograms (right & left)
- Submental and leg myogram
- Electrocardiogram
- Thoracic and abdominal movements
- Oxyhemoglobin saturation
- Nasal airflow
- Sleep position

- Sleep efficiency (percent of time in bed spent asleep;SE)
- Sleep latency (time from lights out to the ®rst epoch of any stage of sleep)
- Percent of total sleep time of stages 1, 2, 3 and 4, REM sleep
- Slow wave sleep (SWS)

Prior to the procedure participant was given a detailed information about the purpose and procedure of polysomnography. He/she was made aware that they will be monitored throughout their sleep and educated about when and how to contact the technologist.

A complete medical history including a detailed sleep history was recorded and a comprehensive clinical examination was done to record the basic vital parameters.

A convenient date was fixed for recording.

Then the participant was given the following set of instructions to be followed on the day of reporting.

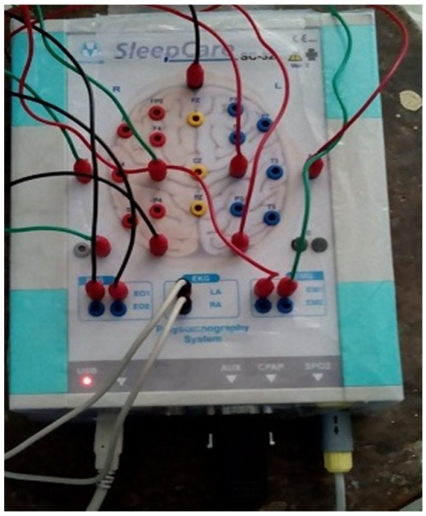
- . To have an evening bath and a clean facial shave.
- . avoid applying oil to any part of the body
- To dine at least an hour before the procedure
- . avoid alcohol on the day of procedure
- . not to take coffee or tea at least 3 hours prior to procedure

- Report with their routine sleep wear
- Remove all ornaments
- To bring all previous medical reports
- Report at the appointed time

Patient tray was kept ready with the following things.

- EEG paste
- Measuring tape
- Cotton swabs
- Electrodes, sensors, and lead wires
- Spirit
- Micropore
- Gloves
- Scissors

Polysomnogram with Head box



Procedure:

The procedure starts with Patient Hookup. It is nothing but the systematic placing of various surface electrodes and sensors on the patient's body.

Electroencephalogram:

EEG is the recording of the electrical activity of neurons using surface electrodes. The pyramidal cells of the cerebral cortex generate EPSP and IPSP. These potentials are recorded through the scalp using the principle of

conductivity. It is noninvasive and the high temporal resolution enables even subtle changes of few milliseconds to be effectively detected. But due to low spatial resolution it requires a large group of neurons to discharge synchronously.

Artifacts like movements of eye, head and muscle, electrical signals from surroundings could contaminate the EEG record and this should be eliminated while making the interpretation. EEG recording is done using eight electrodes-six " exploring " and two "reference" electrodes. The amplitude of the wave forms is dependent on the distance between the two recording electrodes. In order to maximize the inter electrode distance C3 or C4 electrodes used as reference electrode in relation to the opposite mastoid. Always recording is done through two channels so that one can be used as a backup record.

The electrodes used are cup electrodes plated with gold or silver chloride.

According to the R & K criteria the electrode sites are

- Two mastoid/aural (A1, A2)
- Two central (C3, C4)
- Two occipital (O1, O2)

Ideal electrical settings are

Electrode impedance	Less than 500 ohms
Standard gain	Deflection of 1cm for every 50μv
EEG deviations	C4-A1, O2-A1
Electrode for backup	C3-A2

ELECTRODE PLACEMENT

Done according to the International 10-20 system

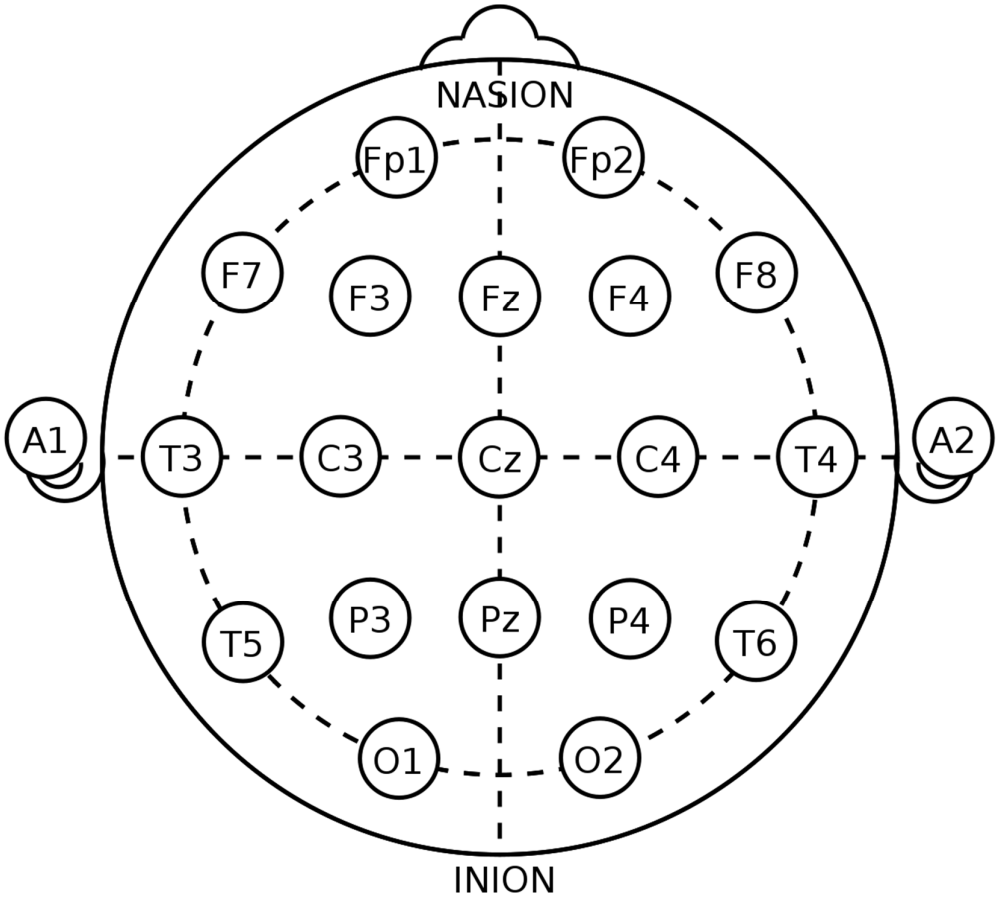


Figure 9 Steps for placement of electrodes

The four landmark locations are-nasion, inion, left preauricular region, and right preauricular region.

Steps to be followed for placement of electrodes are as below.

1. The distance between nasion and inion is measured.
2. Fpz is marked at 10% of this total distance from nasion.
3. Oz is marked at 10% of this total distance from inion.
4. Cz is marked at halfway between nasion and inion.

5. Fpz ,Oz and Cz are along the line joining nasion and inion.
6. Fz is marked at 20% of distance from Cz in the front.
7. Pz is marked at 20% of distance from Cz in the back.
8. Distance between left and right preauricular point was measured (passing through Cz).
9. **C3** is marked at 20% distance from Cz on the **left.**
10. **C4** is marked at 20% distance from Cz on the **right**.
11. T3 is marked at 10% the interauricular distance from the left mastoid
12. T4 is marked at 10% the interauricular distance from the right mastoid.
13. Head circumference is measured through all the 10% points (50% of which coincides with Fpz& Oz in the front and back respectively).
14. **O1** is 5% of the circumference to the **left of Oz**.
15. **O2** is 5% of the circumference to the **right of Oz.**
16. Fp1 is 5% of the circumference to the left of Fpz.
17. Fp2 is 5% of the circumference to the right of Fpz.
18. C3 is 50% of the distance from Fp1to O1 on the interauricular line.
19. F3 is 25% of this distance in the front.
20. P3 is 25% of this distance in the back.
21. C4, F4 & P4 are corresponding points in the right.
22. T5 & T6 are 10% distance of circumference from O1 & O2 in the left & right side respectively.
23. F7 &F8 are 10% distance of circumference from Fp1 & Fp2 in the left & right side respectively.

24. **A1** and **A2** are placed on the **left and right mastoid processes.**

Electrodes are placed in the above mentioned positions. Conventionally the alphabets denote the Frontal, occipital, parietal, temporal ,auricular and central regions.

Odd numbers are used to denote left sided electrodes and even numbers are used for the right side.

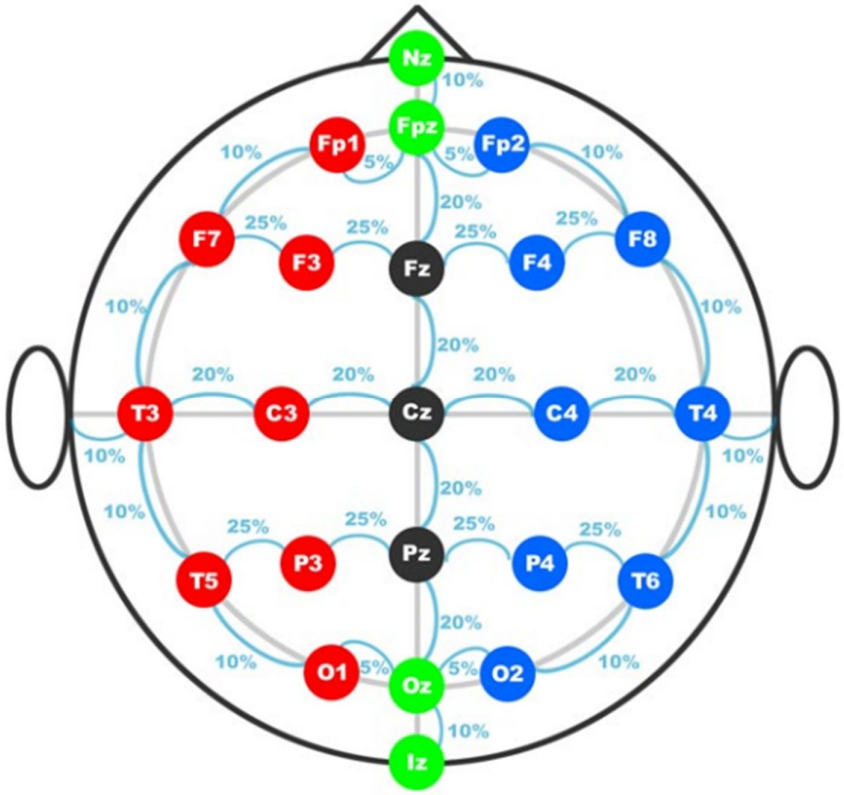


Figure 10:10 -20 System of electrode placement for EEG

Electro oculogram:

- Records the potential difference between the retina and cornea.
- The electrodes for recording are are placed as follows.
- E1-1cm out and below the outer canthus of the left eye.
- E2- 1 cm out and above the outer canthus of right eye.
- Reference electrode is A2.

Electromyogram

- Recorded in the chin and leg.
- Chin EMG needs two electrodes placed 2 cm below the chin; 2 cm right and left of the midline.
- Limb movement is recorded through EMG of anterior tibialis muscle by placing electrodes in the outer aspect of lower half of each leg.

Sensors:

- Sensors are used to measure airflow, oxygen saturation and snoring.

- Non invasive finger probe is used to record the percentage hemoglobin saturated with oxygen.
- Airflow is measured through nasal prongs. A pressure transducer connected to the prongs record the pressure on the prongs created due to flow of air and thus gives an indirect measure of airflow.
- Effort of respiration is measured through expansible belts placed around thorax and abdomen.

- The impedance and signals of all electrodes were checked after placing the electrodes and sensors.
- Biocalibration of the physiological parameters were done at the beginning and end of the procedure. Steps of calibration are
- Close eyes for 30 seconds to reveal α- activity.
- Open eyes for 30 seconds to eliminate α- activity.
- Subjects were instructed to hold head still in midline and move eyes to right and left to mimic REM sleep.
- With head held still in midline ask the subject to move eyes up and down to differentiate horizontal and vertical eye movements.
- Holding a deep breath for 5-10 seconds mimics central apnoea. Moving the chest and abdomen in and out while still breath holding mimics obstructive apneoa.
- Movement of feet are also calibrated.

Documentation of the procedure

Apart from the recording the observer should document the duration of the study procedure, methods of calibration, complaints from the patient , other technical difficulties and measures taken to correct them.

On completion of the recording the data collected should be saved properly and the electrodes and sensors should be cleaned and sterilized.

Analysis of the data and Scoring

Events to be analysed and scored are

- Stages of sleep
- Arousal
- Cardiac events
- Respiratory events
- Movements

SCORING BY EPOCHS

The polygraphic record is analysed in segments called epochs. Each epoch is of 300 mm length and 30 seconds duration.

Each epoch should represent a sleep stage. When more than one stage is present in an epoch the score is determined according to the stage that occupies greater portion of the epoch.

SCORING OF SLEEP STAGES

Awake stage

The epoch consists of **>50% of α EEG waves over theoccipital region when eyes closed**. If α waves are absent look for one of the following

- Eye blinks (0.5-2Hz)
- Slow conjugate eye movement followed by a rapid movement in the opposite direction,
- Rapid open eye movements associated with normal or high chintone.

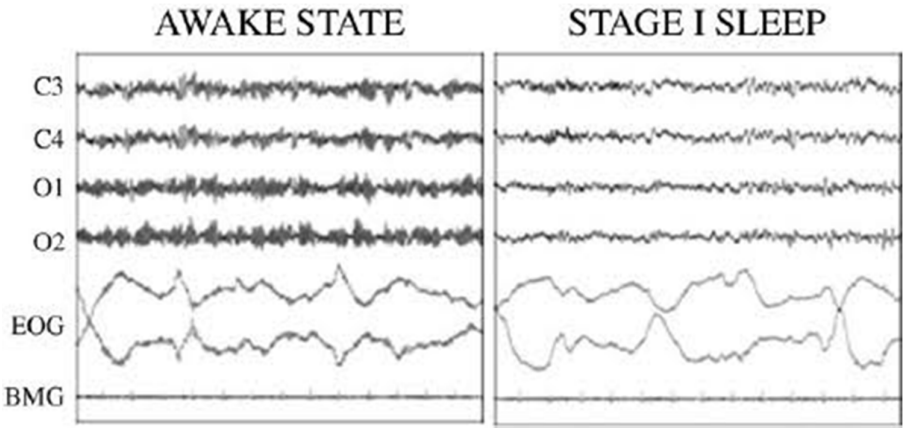


Figure 11 Epoch of stage awake and stage 1

Stage-I-

More than 50% of the epoch is occupied by low amplitude waves of frequencies between 4 to 7 Hz .

If α waves were absent in the awake stage the epoch would show Vertex sharp waves of <0.5 seconds duration maximally over the central region and Slow rolling eye movement.

Stage II-

The epoch consists of K complexes.

As spindles also accompany the K complexes spindles are pathognomonic of this stage.

Except for the eye movement other findings of stage I is also present.

Stage III and IV –

More than 20%of the epoch shows slow waves of 0.5-2Hz and >75uV amplitude.

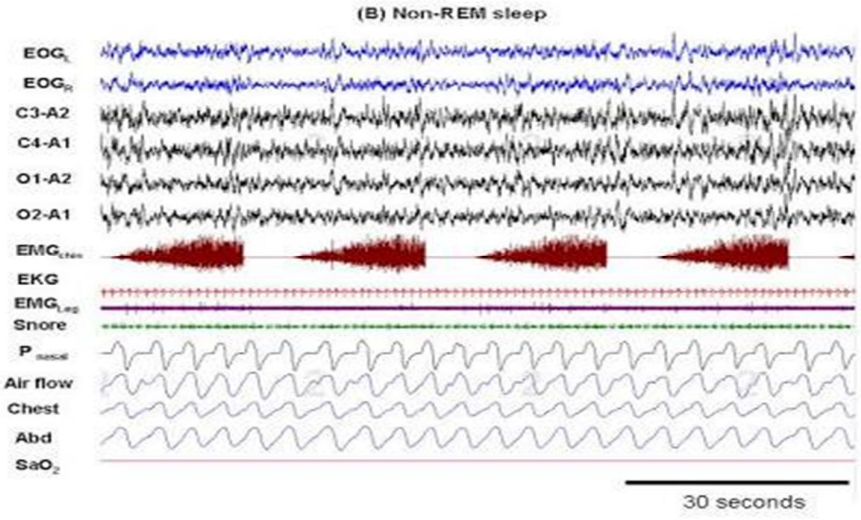


Figure 12 Epoch of Non-REM SLEEP

REM

Epoch would be occupied by waves of low amplitude and mixed frequency.

EOG shows rapid eye movement.

EMG records a reduced tone.

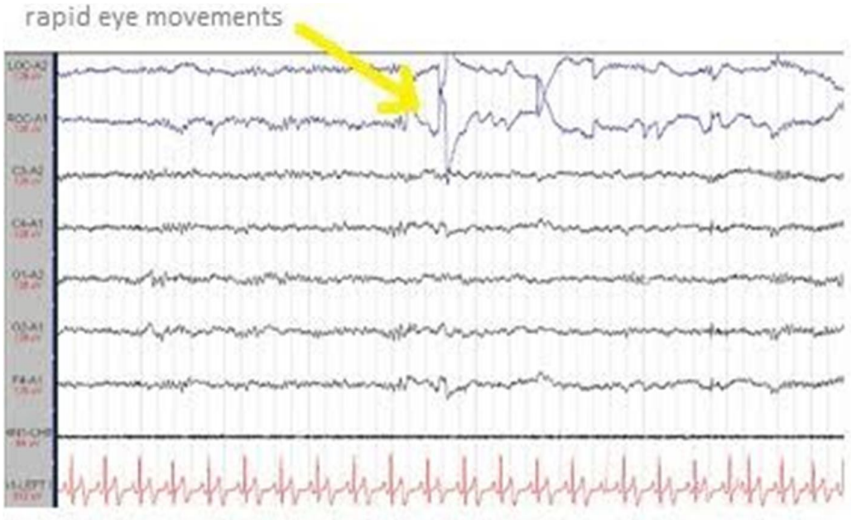


Figure 13 Epoch of REM SLEEP

SCORING RULES FOR RESPIRATORY EVENTS:

More than 90% decrease in amplitude of airflow for atleast 10 seconds is scored as Apnoea.

If this period of apnoea is accompanied by inspiratory effort it is of obstructive type.

If no inspiratory effort is present during this period it is of central type.

Absence of inspiratory effort in the initial period and few efforts in the later part denotes a mixed type.

If airflow amplitude decreases by more than 30% of the normal for atleast 10 seconds along with greater than 4% decrease in oxygen saturation it is scored as hypoapnoea.

Arousal:

Shift in the frequency in an abrupt fashion lasting for > 3 seconds preceded by 10 seconds of stable sleep during NREM sleep is scored as arousal.

This abrupt frequency shift is accompanied by increase in chin EMG for > 1 second if arousal occurs in REM sleep.

Respiratory Effort Related Arousal (RERA)-

Flattening of airflow wave for > 10 seconds but not meeting the criteria for apnoea or hypoapnoea precedes arousal. Sometimes there is heightening of effort of respiration.

Periodic limb movement in sleep

Increase in the amplitude of EMG wave 8μV above the baseline lasting 0.5 to 10 seconds duration consecutively for four times with a gap of 5 to 90 seconds between onset of two movements. If onset of movement on different legs are separated only by < 5 seconds it is considered as single movement.

DEFINITION OF SLEEP ARCHITECHTURE

Sleep Onset	The first three consecutive Epochs of Stage I sleep
Latency to REM	The period of time from sleep onset to first Epoch of REM
NAP onset (Sleep) latency	the period of time to lights out to sleep onset
Sleep Period Time (SPT)	The time from sleep onset to last Epoch of sleep
Total Recording Time (TRT)	The time from lights out to lights on
Total Sleep Time (TST)	The amount of sleep recorded during TRT
Wakefulness After Sleep Onset (WASO)	The Wakefulness occurring from sleep onset to last Epoch of sleep

FORMULAE FOR SCORING

% Stage I	Minutes of Stage I *100/ Total SleepTime (TST)
% Stage II	Minutes of Stage II *100/ Total Sleep Time(TST)
% Stage III & IV	Minutes of Stage III&IV *100/ Total Sleep Time(TST)
% Stage R	Minutes of Stage R *100/ Total Sleep Time(TST)
% Wake time	Minutes of Wake *100/ Sleep Period Time (SPT)

OTHER INDICES

Apnoea Hypoapnoea Index (AHI)	Total number of apnoeas and Hypoapnoeas occurring per hour of sleep
Respiratory Disturbances Index (RDI)	Total number of apnoeas and Hypoapnoeas and Respiratory Effort Related Arousals occurring per hour of sleep
Desaturation Index	Total number of desaturation events per hour of sleep

Subjective Measurement of Sleep

Clinical evaluation of sleep quality in the study participants was done using self reported questionnaires. The instruments used were

- Pittsburgh Sleep Quality Index (PSQI)
- Epworth Sleepiness Scale (ESS)

Pittsburgh Sleep Quality Index (PSQI)

Measure the sleep quality over the past one month. It is 19 item scale which is self reported and consists of an additional 5 items rated by the bed partner but not used for scoring. It is a Likert type that scores seven domains

1. subjective sleep efficiency
2. sleep latency
3. sleep duration
4. sleep quality
5. sleep disturbance
6. sleep medication use
7. daytime dysfunction due to sleepiness

Total score range is 0 to 21. A score of > 5 denotes poor quality of sleep. Higher the score poorer the sleep. With this cut off score of 5 the sensitivity and specificity of PSQI in identifying sleep disorders is 89.6% and 86.5%. it is available in 48 languages across the world and is the widely used scale in large population based studies.

Epworth Sleepiness Scale (ESS):

It is an 8 item self reported scale. It measures the excessive daytime sleepiness. It is also a Likert scale. Each subscale has scores from 0-3. The respondent has to indicate the chances of " doze-off or fall asleep " in eight different real life situations.

1. Sitting reading
2. Watching TV
3. Inactive in public
4. Car passenger
5. Lying down
6. Sitting talking
7. Sitting quietly
8. Car in traffic

Total score range is from 0 – 24. Higher the score higher is the likelihood of daytime sleepiness.

A cutoff score of 10 is taken for indicating excessive sleepiness during the day which is an indirect measure of poor sleep during the night. Higher scores of ESS have been consientantly associated with PSG findings in OSAS, narcolepsy etc. it is also one of the widely used scales in 52 languages across the world.

Results

RESULTS

The data obtained from the above said methods were statistically analysed using SPSS software version 17 statistical significance of the data collected were analysed using UNPAIRED T TEST.

The relationship between individual parameters were analysed by Pearson's rank correlation and Spearman rho's correlation.

Table I : Baseline Parameters

PARAMETER	MEAN	SD
AGE	50.83	± 5.38
BMI	27.1	± 2.99
FBS	154.73	±16.15
PPBS	237.93	± 31.69

In total 30 patients participated in the study. Out of which 16 are males and 14 are females. The mean age of the participants was 50.83 ± 5.38 with mean value of BMI 27.1 ± 2.99. The mean value of FBS was 154.73 ± 16.15. and PPBS was 237.93 ± 31.69.

The mean and standard deviation of the collected data that was included for analysis is as shown in the following table :

Table II: mean and standard deviation of study parameters

S.NO	PARAMETER	MEAN±S.D	
		(CASES)	**(CONTROL)**
1.	N1 (mins) NREM SLEEP	25.93 ± 4.06	18.30 ± 1.83
2.	N2 (mins) NREM SLEEP	141.80 ± 11.04	152.67 ± 9.40
3.	N3 (mins) NREM SLEEP	47.00 ± 10.81	52.23 ± 5.47
4.	REM (mins) SLEEP	64.53 ± 8.01	68.83 ± 4.74
5.	Total sleep time	279.70 ± 26.23	292.03 ± 18.18
6.	Sleep efficiency	74.30 ± 7.11	77.65 ± 3.95
7.	Sleep latency	33.00 ± 9.33	26.80 ± 3.95
8	Diabetes duration	7.73 ± 4.04	-
9.	HbA1c	7.94 ± 0.98	4.72 ± 0.53
10.	PSQI	7.90 ± 3.06	5.37 ± 1.12
11.	ESS	11.90 ± 4.06	9.07 ± 1.79

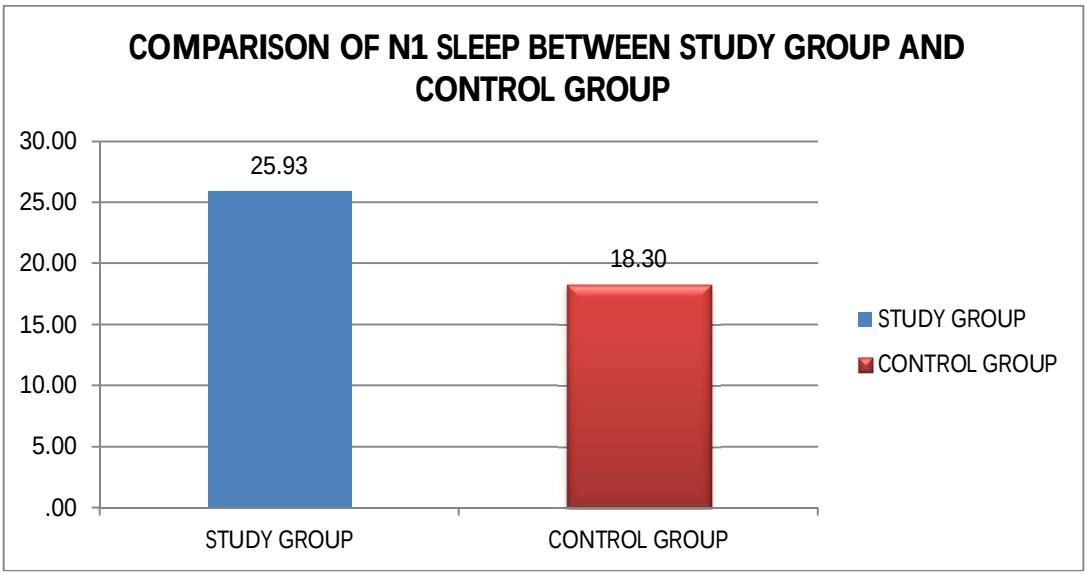
The above parameters were taken for analysis statistically. The correlation of HbA1c and diabetes duration with various sleep parameters have been calculated by PEARSON'S method.

TABLE III: Comparison of sleep stages between study group and control group

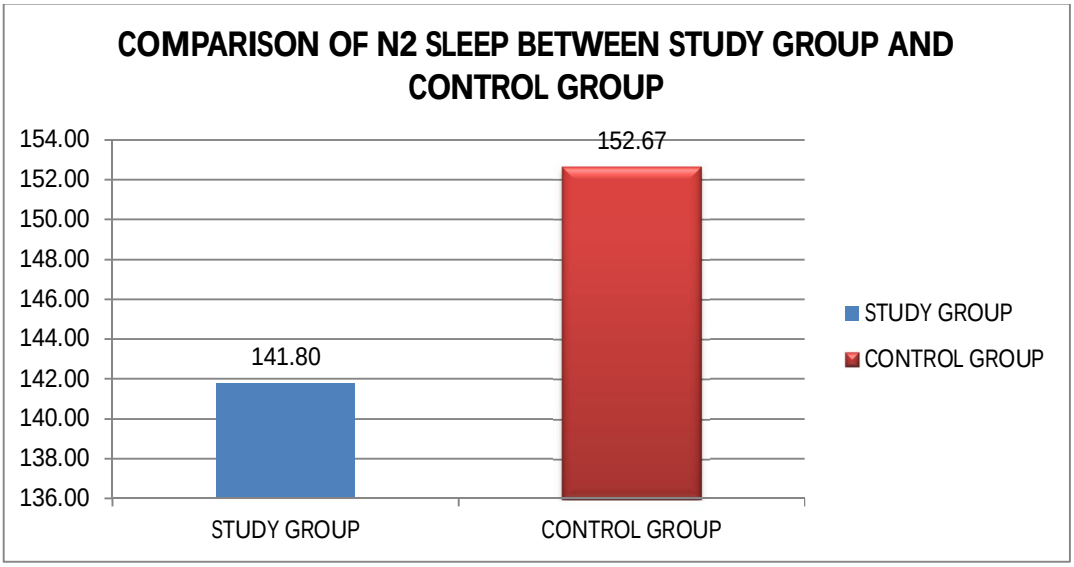
	GROUPING	N	Mean	Std. Deviation	Std. Error Mean	t	DF	p Value
N1(mins)	STUDY GROUP	30	25.93	4.068	.743	9.315	41.038	0.000*
	CONTROL GROUP	30	18.30	1.896	.346			
N2(mins)	STUDY GROUP	30	141.80	11.043	2.016	-4.103	58	0.000*
	CONTROL GROUP	30	152.67	9.404	1.717			
N3(mins)	STUDY GROUP	30	47.20	10.810	1.974	-2.275	42.961	0.028*
	CONTROL GROUP	30	52.23	5.475	1.000			
REM(mins)	STUDY GROUP	30	64.53	8.016	1.464	-2.529	47.084	0.015*
	CONTROL GROUP	30	68.83	4.742	.866			

*p Value Significant at the level <0.05

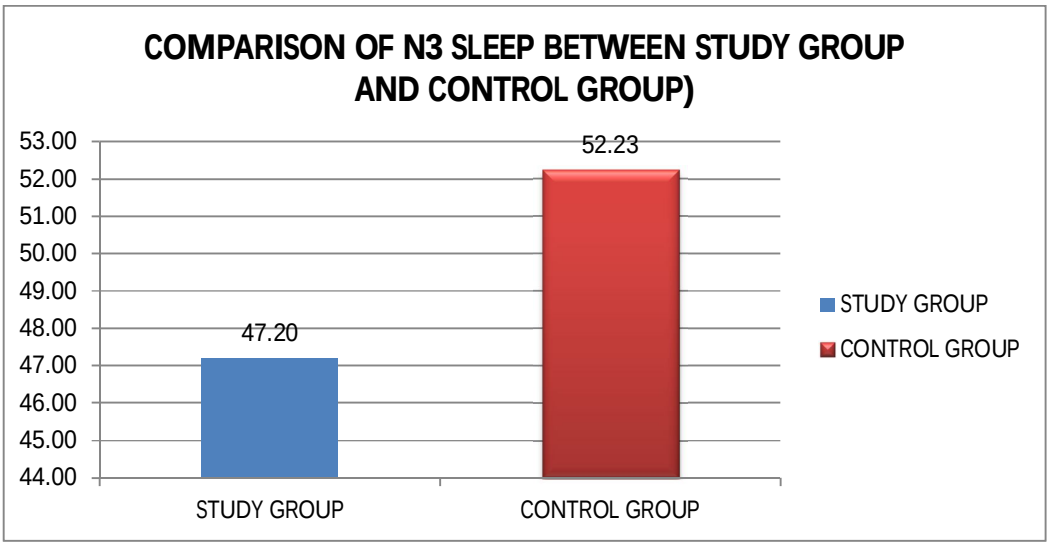
The sleep stages N2 , N3 and REM of study group shows a significant decrease when compared to control group and N1 sleep stage shows a significant increase when compared to control group. (*p-value <0.05)



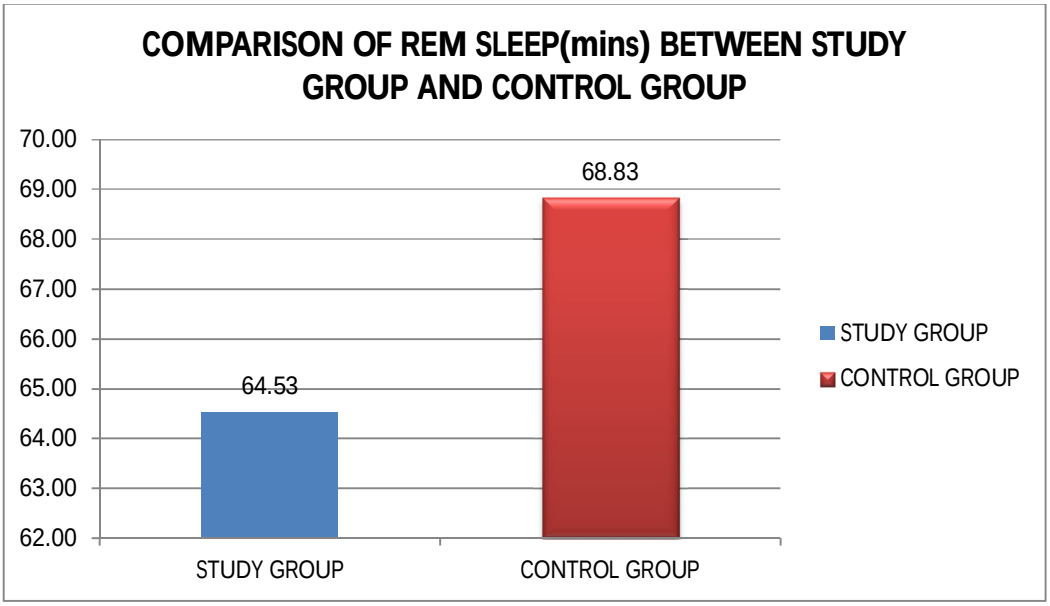
Graph 1 Shows N1 stage of sleep in mins: the mean value of study group (25.93) is higher than that of controls (18.30).



Graph 2 Shows N2 stage of sleep in mins: the mean value of study group (141.80) is lower than that of control group (152.67).



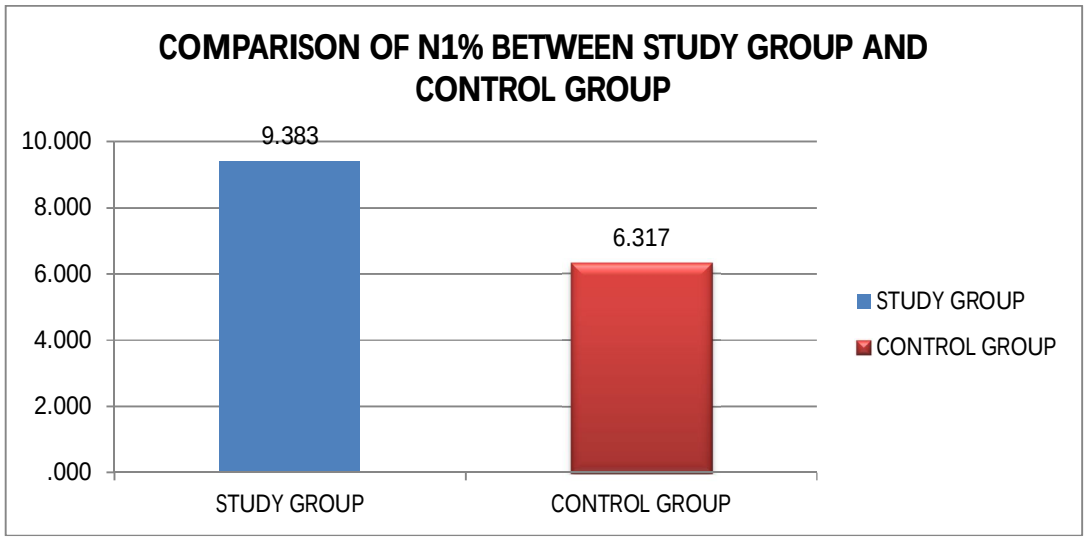
Graph 3 Shows N3 stage of sleep in mins: the mean value of study group (47.20) is lower than that of control group (52.23).



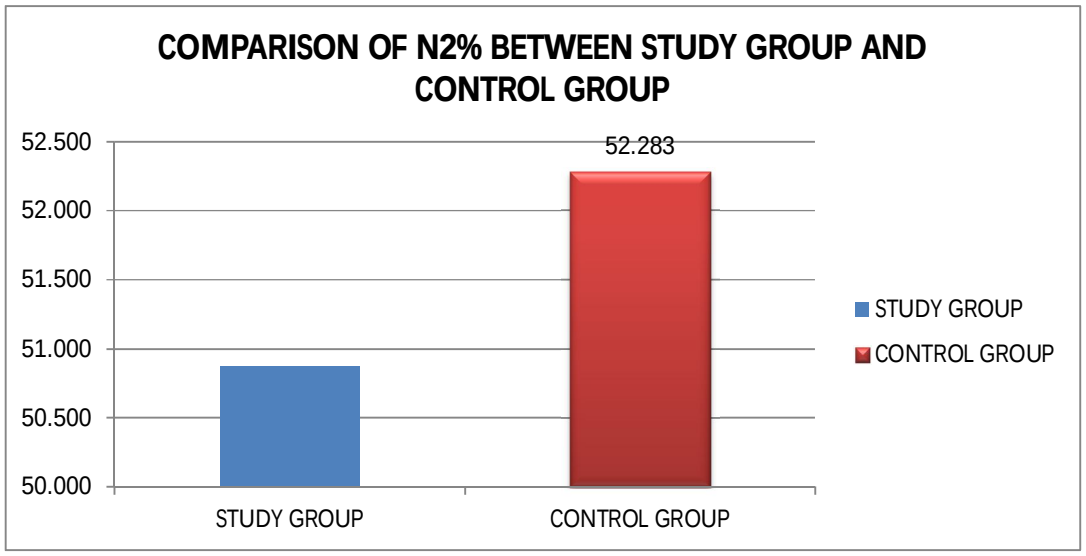
Graph 4 Shows REM stage of sleep in mins: the mean value of study group (64.53) is lower than that of control group (68.83).

TABLE:IV Comparison of percentages of various stages of sleep between study group and control group								
	GROUPING	N	Mean	Std. Deviation	Std. Error Mean	T	DF	p Value
N1%	STUDY GROUP	30	9.383	2.0707	.3780	7.562	37.548	0.000*
	CONTROL GROUP	30	6.317	.8039	.1468			
N2%	STUDY GROUP	30	50.873	1.7426	.3181	-3.949	43.096	0.000*
	CONTROL GROUP	30	52.283	.8875	.1620			
N3%	STUDY GROUP	30	16.697	2.6558	.4849	-2.255	35.461	0.030*
	CONTROL GROUP	30	17.850	.8920	.1629			
REM%	STUDY GROUP	30	23.047	1.1362	.2074	-2.077	47.693	0.043*
	CONTROL GROUP	30	23.550	.6867	.1254			
*p Value Significant at the level <0.05								

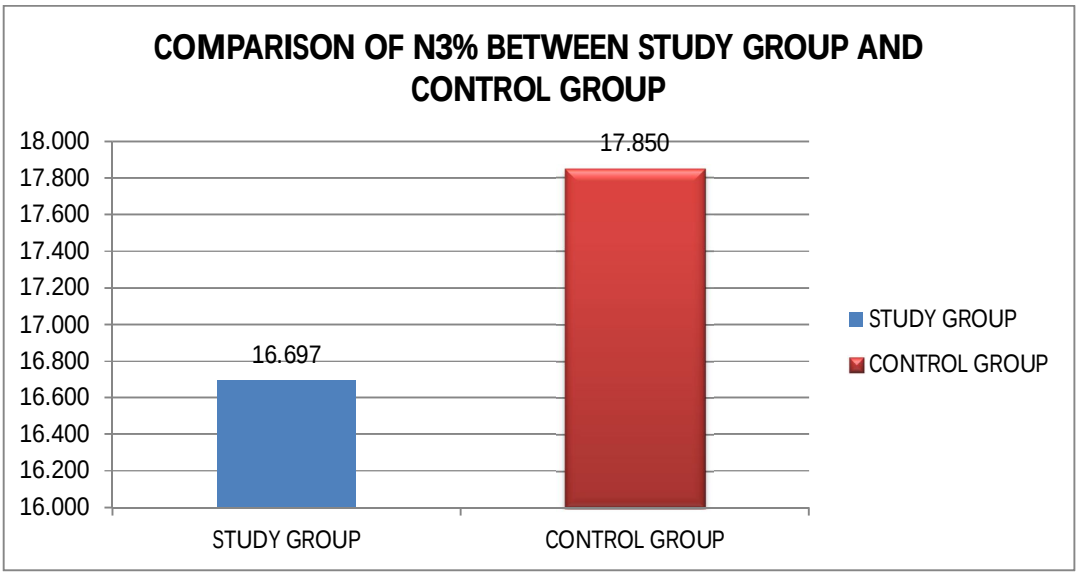
The N2 % , N3% and REM % of study group shows a significant decrease when compared to control group and N1% shows a significant increase when compared to control group ($p<0.05$).



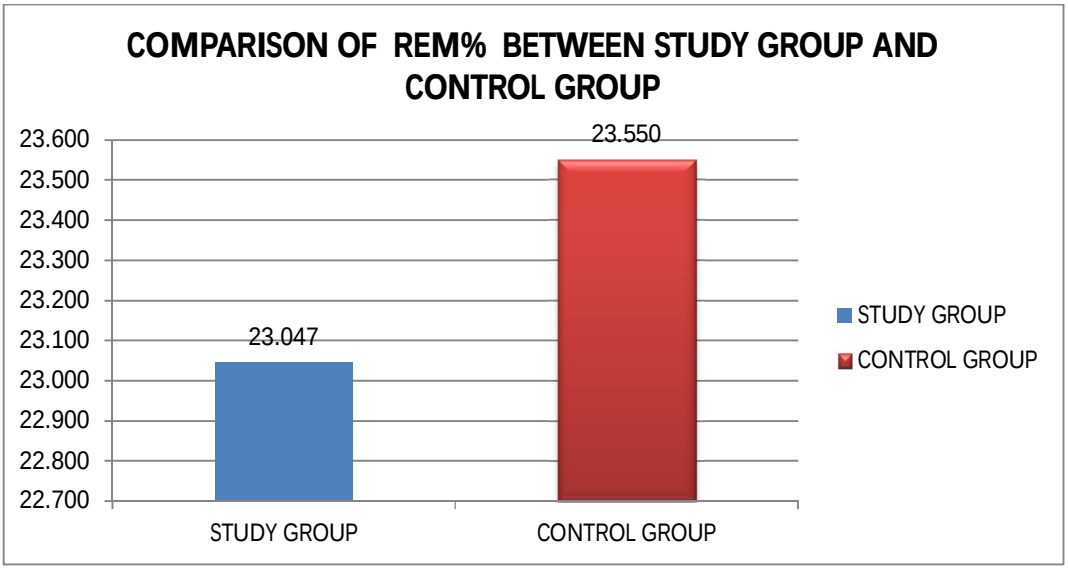
Graph 5 Shows N1% of sleep : the mean value of study group (9.383) is higher than that of control group (6.317).



Graph 6 Shows N2% of sleep : the mean value of study group (50.873) is lower than that of control group (52.283).



Graph 7 Shows N3% of sleep : the mean value of study group (16.697) is lower than that of control group (17.850).



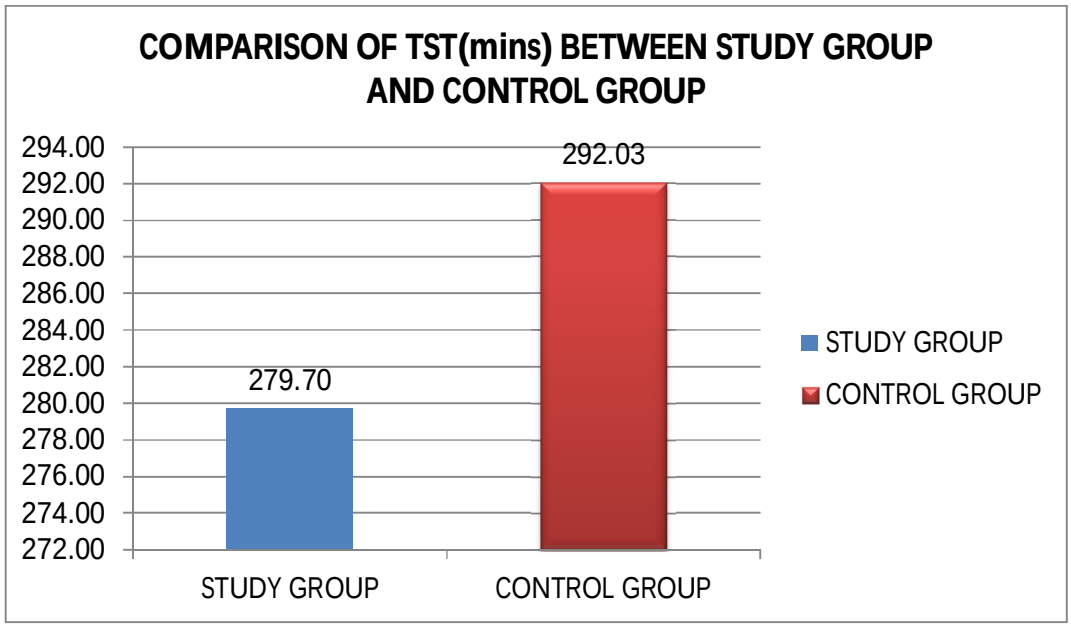
Graph 8 Shows REM% of sleep : the mean value of study group (23.047) is lower than that of control group (23.550).

TABLE:V Comparison of Total sleep time, Sleep efficiency % and sleep latency between study group and control group

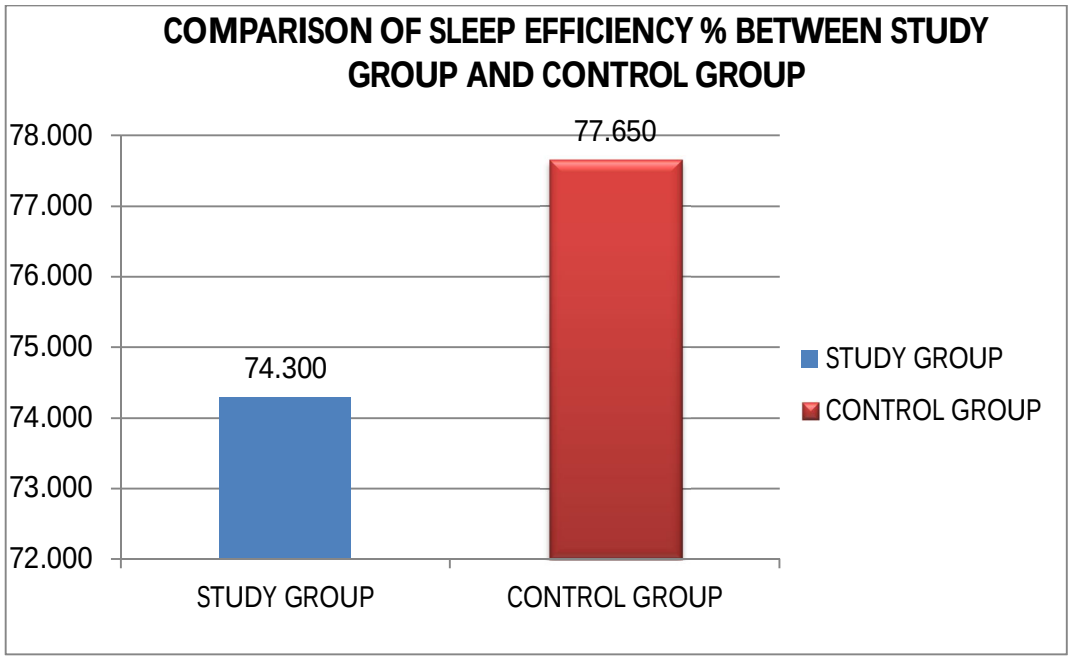
	GROUPING	N	Mean	Std. Deviation	Std. Error Mean	t	DF	p Value
Total sleep time(mins)	STUDY GROUP	30	279.70	26.233	4.789	-2.116	51.647	0.039*
	CONTROL GROUP	30	292.03	18.188	3.321			
sleep efficency %	STUDY GROUP	30	74.300	7.1155	1.2991	-2.255	45.326	0.029*
	CONTROL GROUP	30	77.650	3.9504	.7212			
Sleep latency (mins)	STUDY GROUP	30	33.00	9.337	1.705	3.350	39.066	0.001*
	CONTROL GROUP	30	26.80	3.951	.721			

*p Value Significant at the level <0.05

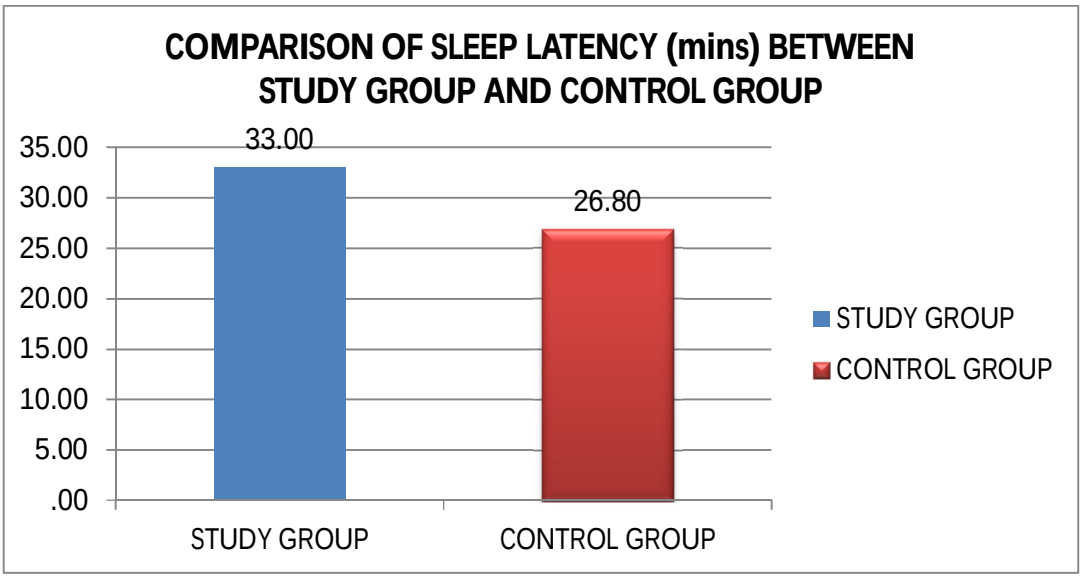
The Total sleep time (TST) , sleep efficiency % of study group shows a significant decrease when compared to control group and sleep latency of study group shows significant increase when compared to control group.(*p-value < 0.05)



Graph 9 Shows Total sleep time in mins: the mean value of study group (279.70) is lower than that of control group (292.03)



Graph 10 Shows sleep efficiency %: the mean value of study group (74.300) is lower than that of control group (77.650)

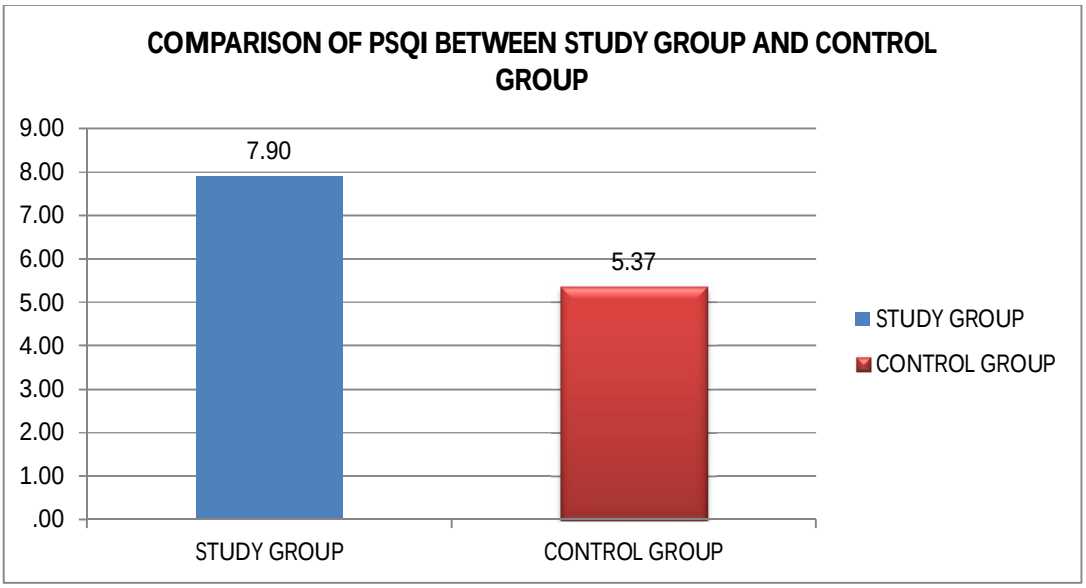


Graph 11Shows Total sleep latency in mins. the mean value of study group (33.00) is higher than that of control group (26.80)

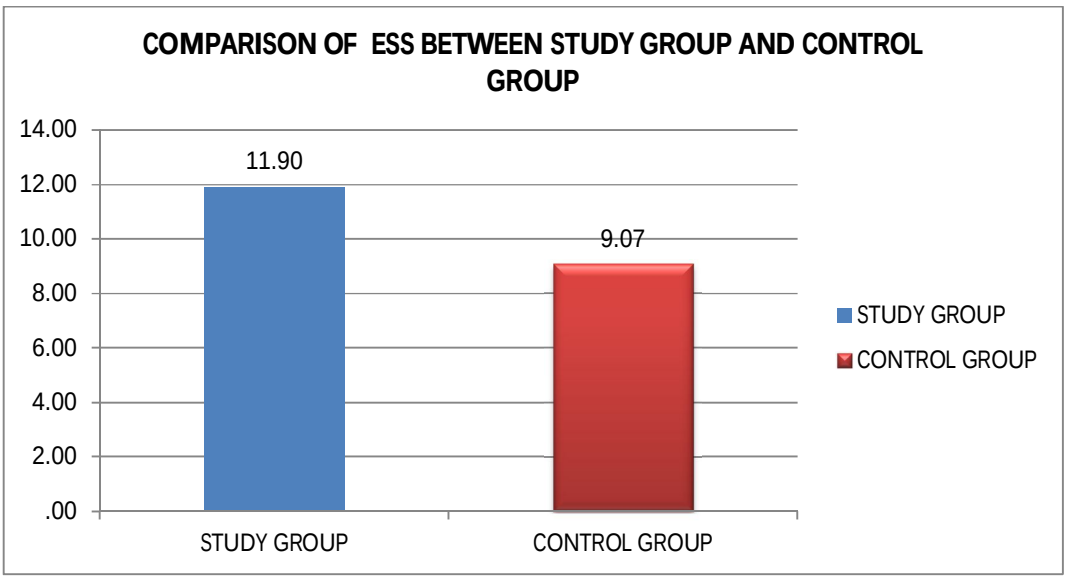
TABLE:VICOMPARISON OF SUBJECTIVE SLEEP SCORES BETWEEN STUDY GROUP AND CONTROL GROUP

	GROUPING	N	Mean	Std. Deviation	Std. Error Mean	T	DF	p Value
PSQI	STUDY GROUP	30	7.90	3.067	.560	4.246	36.720	0.000*
	CONTROL GROUP	30	5.37	1.129	.206			
ESS	STUDY GROUP	30	11.90	4.063	.742	3.493	39.952	0.001*
	CONTROL GROUP	30	9.07	1.799	.328			
*p Value Significant at the level <0.05								

The PSQI and ESS of study group shows a significant increase (*p-value) when compared to control group .



Graph 12 Shows Pittsburgh sleep quality index: the mean value of study group (7.90) is higher than that of control group (5.37)



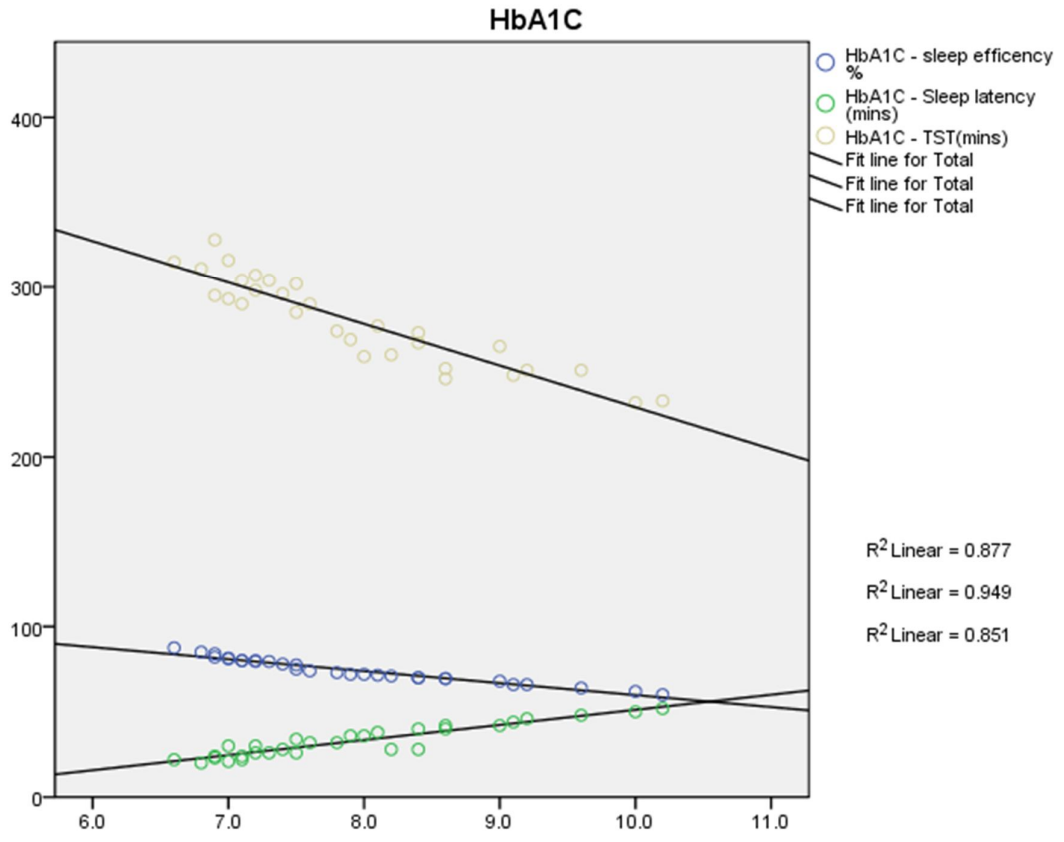
Graph 13 Shows Epworth sleepiness scale: the mean value of study group (11.90) is higher than that of control group (9.07).

TABLE:VII Correlation OF HbA1c and sleep pattern in study group				
		Total sleep time (mins)	Sleep efficiency %	Sleep latency (mins)
HbA1C	Pearson Correlation	-.923**	-.974**	.936**
	Sig. (2-tailed)	.000	.000	.000
	N	30	30	30
		Negative correlation	Negative correlation	Positive correlation

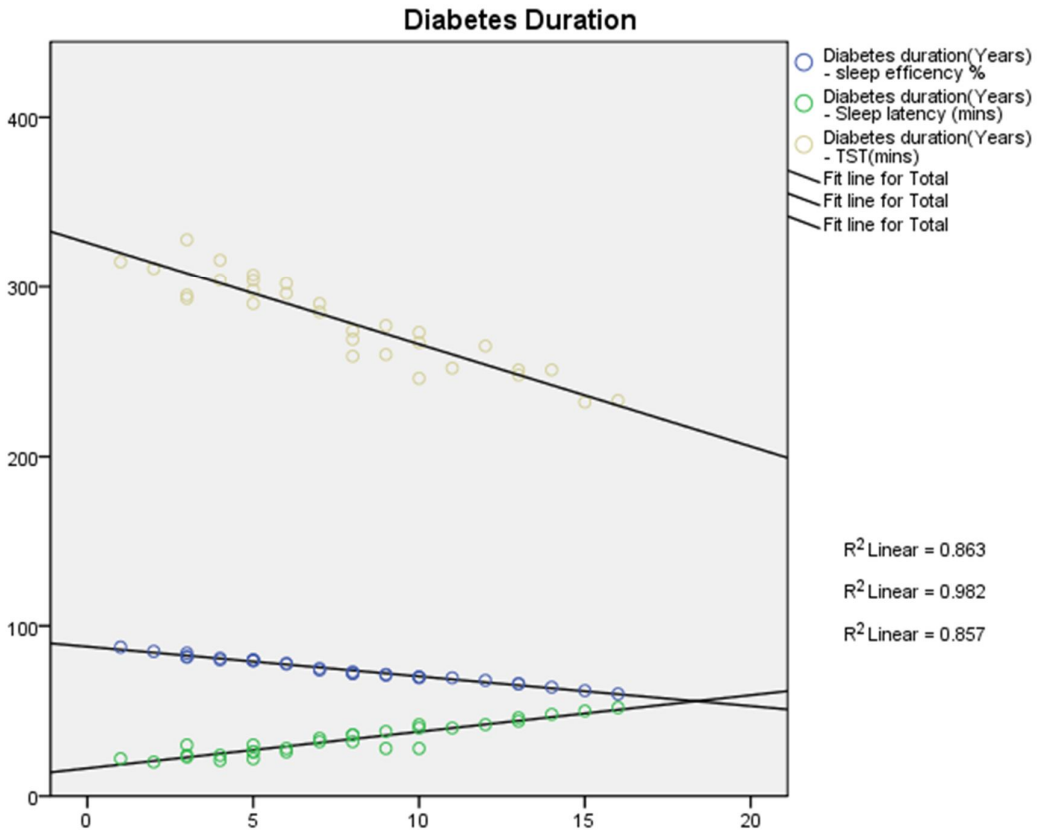
Correlation table of HbA1c with total sleep time, sleep efficiency and sleep latency.Total sleep time(r=-0.923) and sleep efficiency(r=-0.974) shows negative correlation whereas sleep latency (r=0.936) shows positive correlation. The correlation was highly significant with P<0.05 for all three parameters.

TABLE: VIII Correlation of Diabetes duration and sleep pattern in study group				
		Total sleep time (mins)	Sleep efficiency %	Sleep latency (mins)
Diabetes duration (Years)	Pearson Correlation	-.926**	-.991**	.929**
	Sig. (2-tailed)	.000	.000	.000
	N	30	30	30
		Negative correlation	Negative correlation	Positive correlation

Correlation table of Diabetes duration with total sleep time, sleep efficiency and sleep latency. Total sleep time(r=-0.926) and sleep efficiency(r=-0.991) shows negative correlation whereas sleep latency (r=0.929) shows positive correlation. The correlation was highly significant with P<0.05 for all three parameters.



Graph 14 Scatter plotgraph shows correlation of HbA1c and sleep pattern in study group



Graph 15 Scatter plotgraph shows correlation of Diabetes duration and sleep pattern in study group

The analysed results of this study could be summarized as follows.

- The Total Sleep Time (mins) and Sleep efficiency(%) shows a significant decrease in the diabetic patients when compared to the controls.
- With regards to the sleep architecture there is a significant decrease in duration of N2 & N3 stages of non REM sleep(in mins) along with decrease in REM sleep duration in the diabetic group when compared to the control group.
- But there is a significant increase in N1 stage of non REM sleep in the study group in comparison with the controls.
- The diabetic group shows a significant increase in sleep latency when compared with the controls.
- The subjective sleep assessment scores of PSQI and ESS are significantly lower in diabetics than the controls.
- As the duration of diabetes increases there is a decrease in duration and quality of sleep evidenced by decrease in total sleep time and sleep efficiency and increase in sleep latency.
- When there is an increase in HbA1c there is a decrease in duration of sleep and sleep efficiency and increase in sleep latency.

Discussion

DISCUSSION

Maria Pallayova et al [72] analysed polysomnographic recordings of 22 diabetics and 22 non diabetics and found that there was a significant decrease in Slow Wave Sleep (SWS)duration in diabetics compared to normals. The authors have concluded that changes in sleep architecture could be used to predict diabetes at an early stage. In this present study also the duration of SWS is decreased in the diabetic group than the normal group.

Dorit Koren et al [73] have done a study on 62 obese adolescents by measuring the HbA1c, oral glucose tolerance test, serial insulin and glucose levels along with a overnight polysomnography. The authors found a U shaped association between SWS with both HbA1c and glucose levels. There was also a positive association between duration of SWS and insulin secretary measures. Thus the authors concluded that both insufficient and excessive sleep resulted in hyperglycemia. Decreased N3 was associated with insufficient insulin secretion. The present study also replicates the same findings like decreased duration of N2 and N3 stages. Also there was a significant association of HbA1c with duration and quality of sleep.

EsraTasali et al (74)did a study on 9 healthy young non obese individuals to establish the association between sleep architecture and insulin measures. They experimentally suppressed the SWS by using auditory stimuli without disturbing the total duration of sleep. The results showed a marked decrease in insulin sensitivity without any compensatory increase in insulin secretion denoting decreased glucose tolerance that shows an increased risk of diabetes.

Toshiaki Ohkuma et al [(75)] examined the associations of sleep duration and HbA1c levels in 4870 type 2 diabetes patients. They classified the participants according to the duration of sleep vizless than 4.5 h, 4.5–5.4 h, 5.5–6.4 h, 6.5–7.4 h, 7.5–8.4 h, and more than 8.5 h which was self reported. There was a quadratic association of sleep duration with HbA1c with 6.5-7 hr. being the normal comaparator. Both longer and shorter duration of sleep were associated with higher HbA1c. our study also shows that shorter the duration of sleep higher the HbA1c.

Singh et al [(76)] had done a detailed polysomnographic study on 33 diabetic patients in the age group of 40-80 yrs. they found an association with presence of various degrees of OSA in these subjects reflecting a poor quality of sleep. The sleep study parameters showed a decrease in sleep efficiency to approximately 52%. The present study also shows decrease in sleep efficiency with a mean of 74.30 ± 7.11(normal should be atleast 85%). This sleep efficiency is also negatively correlating with HbA1c levels.

Upneet et al[77] studied the quality of sleep and daytime sleepiness in 201 type 2 diabetes patients using PSQI and ESS. They found that around 35% of the study population were reporting daytime sleepiness as evidenced by the ESS score. Consistently the PSQI scores were higher in these patients. This reflects the poor quality of sleep in diabetes patients. In our present study also the scores of PSQI and ESS are higher in the diabetics than the controls.

Bixler et al [78] did a biphasic cohort study on the general population of about 16583 subjects randomly selected through the telephonic register in Pennsylvania. Out of this large cohort 1741subjects with excessive daytime sleepiness were identified and subjected to sleep study in the laboratory ,screened for diabetes, obesity, depression. The authors found a strong association of excessive daytime sleepiness with BMI and Diabetes pointing to the proposal that metabolic syndrome is an important cause for poor sleep quality. In this present study also the scores of ESS are higher in diabetic group than the controls suggesting that diabetes may be a cause for excessive daytime sleepiness.

Bing-Qian Zhu et al [79] investigated the impact of sleep quality on glycemic control in 220 type 2 diabetes patients. Using the PSQI they assessed the quality of sleep and measured HbA1c to assess glycemic control. They found that sleep problems like sleep latency, sleep disturbance and daytime sleepiness were strongly associated with poor glycemic control (HbA1c≥7%). Our study also have

shown that increase in HbA1c is significantly correlated with increase in sleep latency and ESS scores.

Gislason T et al (80)did an epidemiological study on 3201 swedish men to investigate effects of somatic diseases on the sleep quality and pattern. The authors studied effect of COPD, Rheumatic disease, obesity, hypertension and diabetes on sleep. All subgroups had sleep complaints. Among them the diabetic group had problems like Difficulty Initiating Sleep,

Difficulty Maintaining sleep and Excessive Daytime Sleepiness. This is in favour of the results obtained from the present study.

Conclusion

CONCLUSION

From the above discussions the following conclusions could be derived from the present study.

- Type 2 diabetes patients have problems in sleep quality .
- The Total sleep time is decreased than normal controls denoting a reduction in sleep duration in diabetics.
- There is a reduction in Slow wave sleep which denotes that the sleep is not restorative and refreshing in these subjects.
- There is an increase in sleep latency and decrease in sleep efficiency that denotes that diabetics have difficulty in both initiation and maintenance of sleep.
- The above findings in polysomnography are supported by the scores of Pittsburgh sleep quality index (PSQI) and Epworth sleepiness scale (ESS).
- These changes identified in the sleep study could lead to poor glycemic control in type 2 diabetes patients.

Thus patients reporting with sleep difficulties should be screened for diabetes. Type 2 diabetes patients with poor glycemic control should be assessed for sleep disorders and if present it should be corrected to achieve optimum control of blood sugar levels.

LIMITATION OF THE STUDY :

However, the study has got its own limitations as the above findings need to be confirmed with a larger sample size.

Summary

SUMMARY

A study was conducted on thirty type 2 diabetes patients against thirty matches non diabetic controls. The parameters studied were overnight Polysomnography, glycated hemoglobin (HbA1c), Pittsburgh sleep quality index (PSQI) Epworth sleepiness scale (ESS). The results when statistically analysed showed a poor quality of sleep in diabetic patients than controls as there was increased sleep latency, decrease in Total sleep Time with particular reduction in the N2 and N3 phases and decrease in sleep efficiency in the diabetic group than controls. These findings are supported by scores of PSQI and ESS. Also there was a significant association of the sleep abnormalities with glycemic control and duration of diabetes. This indicates patients with diabetes should be screened for sleep problems .The correction of these problems can help the diabetes patients for the better control of hyperglycemic conditions.

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MD1 Yasuhiro Idewaki, MD1 Hitoshi Ide, MD1 Yasufumi DOI, MD, PHD1 Yoichiro Hirakawa, Md3 Udai Nakamura, Md, Phd1 Takanari Kitazono, Md, Phd

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Annexures

INSTITUTIONAL ETHICS COMMITTEE
MADRAS MEDICAL COLLEGE, CHENNAI 600 003

EC Reg.No.ECR/270/Inst./TN/2013
Telephone No.044 25305301
Fax: 011 25363970

CERTIFICATE OF APPROVAL

To
Dr.V.Saravanan
Post Graduate in M.D.Physiology
Institute of Physiology and Experimental Medicine
Madras Medical College
Chennai 600 003

Dear Dr.V.Saravanan,

The Institutional Ethics Committee has considered your request and approved your study titled **" STUDY OF SLEEP PATTERN IN TYPE 2 DIABETES MELLITUS PATIENTS CORRELATION WITH HbA1c" NO. 22062016.**

The following members of Ethics Committee were present in the meeting hold on **07.06.2016** conducted at Madras Medical College, Chennai 3

1.Dr.C.Rajendran, MD.,	:Chairperson
2.Dr.Isaac Christian Moses,MD.Ph.D.Dean(FAC)MMC,Ch-3	:Deputy Chairperson
3.Prof.Sudha Seshayyan,MD., Vice Principal,MMC,Ch-3	:MemberSecretary
4.Prof.B.Vasanthi,MD., Prof.of Pharmacology.,MMC,Ch-3	: Member
5.Prof.P.Raghumani,MS, Prof. of Surgery,RGGGH,Ch-3	: Member
6.Prof.Baby Vasumathi, Director, Inst. of O&G,Ch-8	: Member
7.Prof.K.Ramadevi,MD, Director,Inst.of Bio-Chem,MMC,Ch-3	: Member
8.Prof.M.Saraswathi,MD.,Director, Inst.of Path,MMC,Ch-3	: Member
9.Tmt.J.Rajalakshmi, JAO,MMC, Ch-3	: Lay Person
10.Thiru S.Govindasamy, BA.,BL,High Court,Chennai	: Lawyer
11.Tmt.Arnold Saulina, MA.,MSW.,	:Social Scientist

We approve the proposal to be conducted in its presented form.

The Institutional Ethics Committee expects to be informed about the progress of the study and SAE occurring in the course of the study, any changes in the protocol and patients information/informed consent and asks to be provided a copy of the final report.

28/6/16

Member Secretary - Ethics Committee

MEMBER SECRETARY
INSTITUTIONAL ETHICS COMMITTEE
MADRAS MEDICAL COLLEGE
CHENNAI-600 003

INFORMED CONSENT FORM

Title of the study: A Study of sleep pattern in type 2 diabetes patients and its correlation with HbA1c

Name of the Participant :

Name of the Principal Investigator : Dr.V.SARAVANAN

Name of the Institution :

Institute of Physiology and Experimental Medicine,
Madras Medical College and Govt. General Hospital,
Chennai – 3

Documentation of the informed consent

I _____ have read the information in this form (or it has been read to me). I was free to ask any questions and they have been answered. I am over 18 years of age and, exercising my free power of choice, hereby give my consent to be included as a participant in

A study of sleep pattern in type 2 diabetes patients correlation and its with HbA1c

1. I have read and understood this consent form and the information provided to me.
2. I have had the consent document explained to me.
3. I have been explained about the nature of the study.
4. I have been explained about my rights and responsibilities by the investigator.
5. I have been informed the investigator of all the treatments I am taking or have taken in the past _____ months including any native (alternative) treatment.
6. I have been advised about the risks associated with my participation in this study.
7. I agree to cooperate with the investigator and I will inform him/her immediately if I suffer unusual symptoms.
8. I have not participated in any research study within the past _____month(s).
9. I am aware of the fact that I can opt out of the study at any time without having to give any reason and this will not affect my future treatment in this hospital.
10. I am also aware that the investigator may terminate my participation in the study at any time, for any reason, without my consent.
12. I hereby give permission to the investigators to release the information obtained from me as result of participation in this study to the sponsors, regulatory authorities, Govt. agencies, and IEC. I understand that they are publicly presented.
13. I have understand that my identity will be kept confidential if my data are publicly presented.
14. I have had my questions answered to my satisfaction.
15. I have decided to be in the research study.

I am aware that if I have any question during this study, I should contact the investigator. By signing this consent form I attest that the information given in this document has been clearly explained to me and understood by me, I will be given a copy of this consent document.

For adult participants:

Name and signature / thumb impression of the participant (or legal representative if participant incompetent)

Name _____ Signature_____ Date_____

Name and Signature of impartial witness (required for illiterate patients):

Name _____ Signature_____ Date_____

Address and contact number of the impartial witness:

Name and Signature of the investigator or his representative obtaining consent:

Name _____ Signature_____ Date_____

PROFORMA

1. Name :
2. Age :
3. Sex :
4. Address :
5. Occupation :
6. Complaints/duration :
7. History of present illness :
8. History of day time somnolence:
9. History of snoring from partner:
10. Past history :
11. History of any drug intake :Sleep medications,Anti anxietydrugs,Anti psych iatric drugs
12. History of sweating :
13. History of night terrors:
11. History of associated illness:

    a. Peripheral neuropathy
    b. Hypertension
    c. Ischemic heart disease
    d. Respiratory diseases
    e. Renal diseases
    f. Hypothyroidism

INVESTIGATIONS :

Serum HbA1c levels, Fasting blood sugar, Post prandial sugar,

EXAMINATION :

General examination:

Temperature :

Pulse rate :

Blood pressure :

Body mass index :

Systemic examination:

Cardiovascular system :

Respiratory system :

Gastrointestinal system :

Central nervous system :

Name_____ Date_____

Sleep Quality Assessment (PSQI)

What is PSQI, and what is it measuring?

The Pittsburgh Sleep Quality Index (PSQI) is an effective instrument used to measure the quality and patterns of sleep in adults. It differentiates "poor" from "good" sleep quality by measuring seven areas (components): subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medications, and daytime dysfunction over the last month.

INSTRUCTIONS:

The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions.

During the past month,

1. When have you usually gone to bed? _____
2. How long (in minutes) has it taken you to fall asleep each night? _____
3. What time have you usually gotten up in the morning? _____
4. A. How many hours of actual sleep did you get at night? _____
   B. How many hours were you in bed? _____

5. During the past month, how often have you had trouble sleeping because you	Not during the past month (0)	Less than once a week (1)	Once or twice a week (2)	Three or more times a week (3)
A. Cannot get to sleep within 30 minutes				
B. Wake up in the middle of the night or early morning				
C. Have to get up to use the bathroom				
D. Cannot breathe comfortably				
E. Cough or snore loudly				
F. Feel too cold				
G. Feel too hot				
H. Have bad dreams				
I. Have pain				
J. Other reason (s), please describe, including how often you have had trouble sleeping because of this reason (s):				
6. During the past month, how often have you taken medicine (prescribed or "over the counter") to help you sleep?				
7. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?				
8. During the past month, how much of a problem has it been for you to keep up enthusiasm to get things done?				
9. During the past month, how would you rate your sleep quality overall?	Very good (0)	Fairly good (1)	Fairly bad (2)	Very bad (3)

Scoring

Component 1	#9 Score	C1 _____
Component 2	#2 Score (<15min (0), 16-30min (1), 31-60 min (2), >60min (3)) + #5a Score (if sum is equal 0=0; 1-2=1; 3-4=2; 5-6=3)	C2 _____
Component 3	#4 Score (>7(0), 6-7 (1), 5-6 (2), <5 (3)	C3 _____
Component 4	(total # of hours asleep) / (total # of hours in bed) x 100 >85%=0, 75%-84%=!, 65%-74%=2, <65%=3	C4 _____
Component 5	# sum of scores 5b to 5j (0=0; 1-9=1; 10-18=2; 19-27=3)	C5 _____
Component 6	#6 Score	C6 _____
Component 7	#7 Score + #8 score (0=0; 1-2=1; 3-4=2; 5-6=3)	C7 _____

Add the seven component scores together _____ *Global PSQI* _____

A total score of "5" or greater is indicative of poor sleep quality.
If you scored "5" or more it is suggested that you discuss your sleep habits with a healthcare provider

THE EPWORTH SLEEPINESS SCALE

How likely are you to doze off or fall asleep in the following situations, in contrast to feeling just tired? This refers to your usual way of life in recent times. Even if you have not done some of these things recently try to work out how they would have affected you. Use the following scale to choose the most appropriate number for each situation:

0 = no chance of dozing
1 = slight chance of dozing
2 = moderate chance of dozing
3 = high chance of dozing

SITUATION	CHANCE OF DOZING
Sitting and reading	_____
Watching TV	_____
Sitting inactive in a public place (e.g a theater or a meeting)	_____
As a passenger in a car for an hour without a break	_____
Lying down to rest in the afternoon when circumstances permit	_____
Sitting and talking to someone	_____
Sitting quietly after a lunch without alcohol	_____
In a car, while stopped for a few minutes in traffic	_____

To check your sleepiness score, total the points . Check your total score to see how sleepy you are.

1 - 6	Congratulations, you are getting enough sleep!
7 - 8	Your score is average
9 and up	Seek the advice of a sleep specialist without delay

Another Version's Answer Key was:

If your score is greater than 6 points then you are sleepy. If your score is more than 10 points you are very sleepy. If your score is more than 16 points you are dangerously sleepy. If your score doesn't improve after 2 weeks of 8 hours of sleep a night, it is recommended that you consult your doctor.

ஆராய்ச்சி ஒப்புதல் படிவம்

ஆராய்ச்சி தலைப்பு :

பாலிசோம்னோகிராஃபி மற்றும் இரத்தத்தில் HbA1c, FBS, PPBS அளவை நீரிழிவு நோயாளிகளிடம் ஆராய்ந்து அறிதல்.

பெயர் :

வயது :

பாலினம் : ஆண் / பெண்

பங்கு பெறுபவர் அடையாள எண். :

இந்த ஆராய்ச்சியின் விவரங்களும் அதன் நோக்கமும் முழுமையாக எனக்கு தெரிவிக்கப்பட்டது.

எனக்கு விளக்கப்பட்ட விஷயங்களை புரிந்துக்கொண்டு நான் எனது சம்மதத்தை தெரிவிக்கிறேன்.

எனது பாலிசோம்னோகிராஃபி மற்றும் இரத்தத்தில் HbA1c, FBS, PPBS அளவை பரிசோதனை செய்ய முழு சம்மதம்.

இந்த, ஆராய்ச்சியில் யாருடைய நிர்பந்தமும் இன்றி சொந்த விருப்பத்தின் பேரில் சம்மதிக்கிறேன்.

இந்த ஆராய்ச்சியில் இருந்து நான் எந்த நேரமும் பின்வாங்கலாம் என்றும், அதனால் எந்த பாதிப்பும் ஏற்படாது என்பதையும் புரிந்துக்கொண்டேன்.

நான் தூக்கம் குறித்த இந்த ஆராய்ச்சியின் விவரங்கள் கொண்ட தகவல்களை பெற்றுக்கொண்டேன்.

இரத்தத்தில் HbA1c, FBS, PPBS அளவை பரிசோதனை செய்ய சம்மதிக்கிறேன். இரத்தம் எடுக்கும்போது வலி, மயக்கம் போன்ற பின்விளைவுகள் ஏற்படலாம் என்பதை தெரிந்துக்கொண்டேன்.

நான் என்னுடைய சுயநினைவுடன் மற்றும் முழு சம்மதத்துடன் இந்த ஆராய்ச்சிக்கு என்னை பரிசோதிக்க சம்மதிக்கிறேன்.

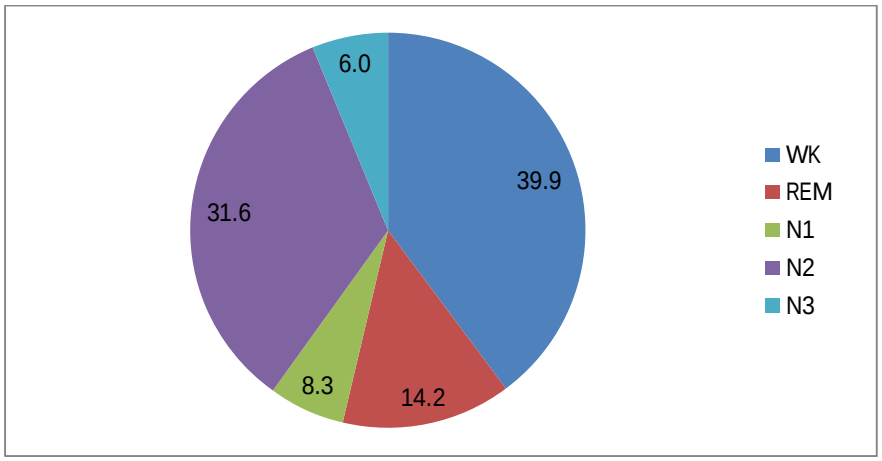
பங்கேற்பாளர் கையொப்பம்

POLYSOMNOGRAPHY REPORT

Patient Name:	Shankar		
Sex:	M	**Study Date:**	31-01-2017
D.O.B.	01-06-1959	**Study Type:**	DIAGNOSTIC
Age:	57 years		
Height:	162.0 cm	**Referring Physician:**	Prof.Dr. P.Dharmarajan
Weight:	82.0 kgs	**Interpreting Physician:**	Dr. V.Saravanan
B.M.I:	31.2 kg/m^2		

SLEEP ARCHITECTURE	
Lights off clock time:	22:48:13
Lights on clock time:	05:14:13
Total Recording Time (TRT):	386 minutes
Time In Bed (TIB):	386 minutes
Total Sleep Time (TST):	232.0 minutes
Sleep Efficiency:	62 %
Sleep Latency:	50.0 minutes

Sleep Staging	Duration	% TST
N 1:	32.0 minutes	14.0 %
N 2:	122.0 minutes	52.5%
N 3:	23.0 minutes	10.0%
R:	55.0 minutes	23.5 %



MASTER CHART - CASES (TYPE II DIABETES)

S. No.	age (Years)	sex	BMI	N1 (mins)	N2 (mins)	N3 (mins)	REM (mins)	N1%	N2%	N3%	REM %	TST (mins)	sleep efficency %	Sleep latency (mins)	Diabetes duration (Years)	FBS (mg/dl)	PPBS (mg/dl)	HbA1C	PSQI	ESS
1	41	m	18.6	27	167	57	77	8	51	17.5	23.5	328	84	23	3	136	208	6.9	4	7
2	57	m	31.2	32	124	24	52	14	53.5	10	22.5	232	62	50	15	192	324	10	13	18
3	46	f	29	24	147	54	73	8	49.5	18	24.5	298	80	26	5	142	210	7.2	5	7
4	45	f	25.7	28	150	50	67	9.5	51	17	22.5	295	82	24	3	136	210	6.9	4	7
5	60	f	29.7	28	120	26	52	12.5	53	11.5	23	233	60	52	16	180	310	10.2	14	18
6	46	m	23.7	25	144	54	70	8.5	49	18.5	24	293	81.5	30	3	136	202	7	5	8
7	60	f	28.1	17	129	42	58	7	52.5	17	23.5	246	69.5	42	10	164	260	8.6	11	16
8	52	f	26.1	20	134	53	67	7	49	19.5	24.5	274	73	32	8	152	230	7.8	8	12
9	52	f	27.3	29	138	31	53	11.5	55	12.5	21	251	66	46	13	172	270	9.2	12	18
10	57	f	28.5	21	126	44	61	8.5	50	17.5	24	252	69.5	40	11	186	286	8.6	10	15
11	42	m	27.6	24	156	60	76	7.5	49.5	19	24	316	81	21	4	140	210	7	5	7
12	53	m	25.7	26	135	46	62	9.5	50.5	17	23	269	72	36	8	158	246	7.9	8	13
13	45	f	29.4	23	157	61	70	7.5	50.5	19.5	22.5	311	85	20	2	132	206	6.8	3	6
14	58	m	31.3	34	128	32	54	13.5	51.5	13	22	248	66	44	13	168	252	9.1	11	18
15	49	m	24.8	23	148	51	68	8	51	17.5	23.5	290	80	22	5	140	208	7.1	5	8
16	50	f	28.1	29	155	52	68	9.5	51	17	22.5	304	80	24	4	146	212	7.1	5	8
17	50	f	28.1	30	144	37	54	11.5	54	14	20.5	265	68	42	12	162	236	9	11	16
18	58	m	25.4	27	137	48	65	9.5	49.5	17.5	23.5	277	71.5	38	9	168	270	8.1	9	13
19	56	f	28.2	25	134	45	63	9.5	50	17	23.5	267	70	28	10	160	256	8.4	10	14
20	51	f	26.4	24	148	59	71	8	49	19.5	23.5	302	77.5	26	6	150	224	7.5	7	11
21	45	m	27.3	27	137	40	55	10.5	53	15.4	21.1	259	72	36	8	142	220	8	9	13
22	43	m	23.1	24	156	61	74	7.5	49.5	19.5	23.5	315	87.5	22	1	130	202	6.6	3	6
23	46	m	24.1	22	147	61	74	7	48.5	20	24.5	304	79.5	26	5	146	216	7.3	6	9
24	55	m	27.7	23	132	44	61	9	50.5	17	23.5	260	71	28	9	160	250	8.2	9	14
25	48	m	31.2	34	139	41	59	12.5	51	15	21.5	273	70	40	10	150	224	8.4	10	14
26	53	m	21	27	144	50	64	9.5	50.5	17.5	22.5	285	75	34	7	154	232	7.5	7	12
27	54	f	31.1	33	135	30	53	13	53.7	12	21.3	251	64	48	14	178	268	9.6	12	18
28	53	m	26.7	22	147	54	67	7.5	51	18.5	23	290	74	32	7	156	240	7.6	8	12
29	50	m	29	25	147	60	75	8	48	19.5	24.5	307	79.5	30	5	150	220	7.2	6	9
30	50	f	29.7	25	149	49	73	8.5	50.5	16.5	24.5	296	78	28	6	156	236	7.4	7	10

MASTER CHART - CONTROL (NON DIABETIC)

S. No.	age (Years)	sex	BMI	N1 (mins)	N2 (mins)	N3 (mins)	REM (mins)	N1%	N2%	N3%	REM%	TST (mins)	sleep efficency %	Sleep latency (mins)	FBS (mg/dl)	PPBS (mg/dl)	HbA1C	PSQI	ESS
1	52	m	28.4	19	151	48	67	6.5	53	17	23.5	285	78	26	100	162	5.1	6	10
2	49	m	27.3	20	161	55	76	6.5	51.5	17.5	24.5	312	80	28	82	146	4.2	4	6
3	42	f	31.2	15	177	67	75	4.5	53	20	22.5	334	88	20	78	146	4	4	6
4	47	m	30.8	19	154	50	70	6.5	52.5	17	24	293	78	28	96	160	4.5	5	9
5	50	f	30.4	16	148	48	62	6	54	17.5	22.5	274	76	28	96	164	4.8	6	10
6	44	m	28.3	19	164	59	78	6	51	18.5	24.5	320	82	22	84	148	4.1	4	7
7	54	f	33.7	18	138	49	65	6.5	51.5	18	24	270	75	32	98	164	5.1	6	10
8	56	m	26.9	22	153	49	65	7.5	53	17	22.5	289	74	31	102	172	5.4	6	11
9	50	f	30.3	15	155	53	71	5	53	18	24	294	78.5	25	90	162	4.5	5	8
10	44	m	29.1	19	163	55	73	6	52.5	18	23.5	310	81.5	24	86	150	4.1	4	7
11	41	f	30.5	17	174	65	79	5	52	19.5	23.5	335	86	18	72	142	3.8	4	7
12	54	m	27.6	18	141	44	60	7	53.5	17	22.5	263	73	32	102	168	5.2	6	10
13	47	f	30.8	20	160	51	71	6.5	53	17	23.5	302	78.5	29	94	156	4.5	5	10
14	56	m	28.3	21	149	46	64	7.5	53	16.5	23	280	72	27	104	170	5.3	7	11
15	49	f	28.3	17	153	50	68	6	53	17.5	23.5	288	79	29	90	152	4.4	5	9
16	46	m	28.3	18	146	51	66	6.5	52	18	23.5	281	76	32	98	160	4.8	6	11
17	58	f	32.9	16	141	46	66	6	52.5	17	24.5	269	71.5	26	104	176	5.4	8	12
18	54	m	29	21	144	50	70	7.5	50.5	17.5	24.5	285	73.5	30	102	168	5.3	6	10
19	49	f	31.2	20	158	55	71	6.5	52	18	23.5	304	79.5	27	94	154	4.4	5	9
20	52	m	28.3	19	149	49	69	6.5	52	17	24.5	286	74	31	100	162	5	6	10
21	55	m	27.3	20	144	48	62	7.5	52.5	17.5	22.5	274	76	30	104	182	5.5	5	9
22	50	f	32.9	20	145	53	69	7	50.5	18.5	24	287	77.5	25	96	156	4.6	6	10
23	50	m	31.2	18	155	56	71	6.5	51.5	18.5	23.5	300	78	25	90	160	4.6	6	9
24	45	m	29.8	17	163	60	74	5.5	52	19	23.5	314	80	23	86	148	4.2	4	6
25	48	f	27.4	16	147	56	69	5.5	51	19.5	24	288	79.5	24	84	154	4.3	5	9
26	59	m	29.7	20	145	45	61	7.5	53.5	16.5	22.5	271	71	32	106	186	5.6	8	13
27	44	m	29.7	15	156	55	69	5	53	18.5	23.5	295	82	20	80	150	4.2	4	7
28	47	f	31.7	19	153	52	67	6.5	52.5	18	23	291	79	22	82	146	4.1	4	7
29	52	m	28.7	17	151	54	69	6	52	18.5	23.5	291	77	27	102	166	5.2	5	9
30	55	f	30.3	18	142	48	68	6.5	51.5	17.5	24.5	276	75.5	31	106	180	5.4	6	10